INDIAN PHYTOPATHOLOGY

VOLUME II 1949 NUMBER 2

PUBLISHED FOR

THE INDIAN PHYTOPATHOLOGICAL SOCIETY
PUSA BUILDINGS, NEW DELHI 5
INDIA

TABLE OF CONTENTS

PAGE

U. B. Singh (Obituary).—R. Prasada 107

Morphology and Cytology of Entyloma microsporum (Unger) Schroet. and Urocystis anemones (Pers.) Winter on Ranunculus repens L.—M. C. Das. 108

A chytridiaceous parasite on Limnanthemum indicum.—M. J. Thirumalachar. 128

Stomatal invasion of cabbage by Xanthomonas campestris (Pammel) Dowson.—V. P. Bhide 132

Studies in aquatic Phycomycetes.—R. C. Lacy 134

Fungi of Bombay, Supplement I.—M. K. Patel, M. N. Kamat and V. P. Bhide. 142

Notes on two fungi parasitic fungi on scale insects.—M. J. Thirumalachar .. 156

Partial vitamin deficiencies in four strains of Colletotrichum lindemuthianum. —R. S. Mathur, Virgil Greene Lilly and H. L. Barnett. 160

Bacterial leaf spot of lucerne.—M. K. Patel, Y. S. Kulkarni and G. W. Dhande 166

Bacterial leaf spot of Desmodium diffusum DC.—M. K. Patel 168

Utilization of organic nitrogen by Corynebacterium michiganense (E. F. S.) Dowson and its possible bearing on parasitism.—V. P. Bhide 173

Four new species of fungi from Bombay.—B. N. Uppal, M. K. Patel and V. P. Bhide 176

A new strain of Cucumis virus 2.—R. S. Vasudeva, S. P. Raychaudhuri and Jagannath Singh 180

The validity of the name Pellicularia koleroga Cooke.—S. V. Venkatarayan. 186

Some parasitic fungi collected in the vicinity of Banaras.—M. M. Payak .. 190

Genera of Rusts II.—M. J. Thirumalachar and B. B. Mundkur 194

First record of Verticillium wilt in India.—M. K. Patel, I. M. Qureshi and V. P. Bhide 245

Book Review : Fungi and Plant Disease 247

Financial statement for 1947 and 1948. 248

IMPERIAL CHEMICAL INDUSTRIES (INDIA) LTD

I.C.I. (India) Ltd. have been playing a leading role in the agricultural field in this country. With the establishment of Plant Protection Organisations throughout the country, they now offer the following Plant Protection Products which have been successfully tried under Indian conditions:—

'PERENOX'

A water dispersible Cuprous Oxide powder containing 50% Copper, controls Blister Blight of Tea, Late Blight of Potatoes and other fungous diseases.

'SULFINETTE'

A ready for use Lime/Sulphur wash containing 25/28% polysulphide sulphur, controls fungous diseases of deciduous fruits, coffee, tea etc. as well as Red Spider.

'AGROXONE'

A hormone selective weed-killer containing Sodium salt of Methoxone, controls Water Hyacinth, Striga on Sugarcane and Jowar and number of other weeds.

'AGROSAN' GN

An organo-mercurial dry seed dressing, controls seed-borne diseases and increases germination percentage and yield.

'FERNOXONE'

A hormone selective weed-killer containing 80% Sodium salt of 2,4-D, controls Water Hyacinth, Striga and other weeds.

'PHYOMONE'

A synthetic hormone preparation containing a-naphthylacetic acid for reducing pre-harvest Fruit Drop.

PRODUCTS OF PLANT PROTECTION LTD

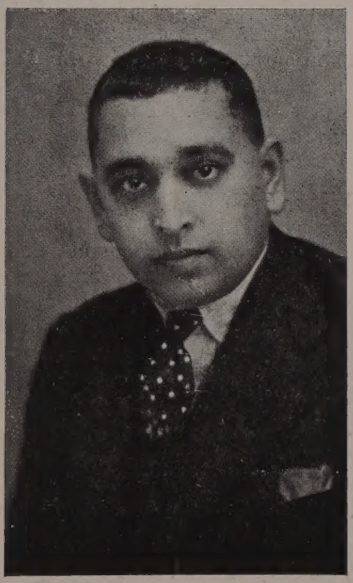
Sole Agents in India

IMPERIAL CHEMICAL INDUSTRIES (INDIA) LTD

CALCUTTA BOMBAY MADRAS KANPUR NEW DELHI COCHIN

DR U. B. SINGH, 1904—1949

THE passing away of a friend who had lead a full and useful life causes regret among friends, but when death comes prematurely to one who had shown promise of good work and a major part of whose usefulness had yet to be fulfilled, then the shock is very severe. When news came therefore that Dr U. B. Singh passed away at the early age of 45, on the 26th March 1949, after a brief illness, all his friends throughout India felt it as a personal loss which could not be easily replaced.



Dr U. B. SINGH, 1904-1949

Uday Bhan Singh, Plant Pathologist to the Government of U. P., belonged to a highly educated and respectable family of Allahabad. His father, the late Dr Daulat Singh, was a medical practitioner. After his father's early death his elder brother was young Uday Bhan's guardian. The death of this elder brother, to whom he was much devoted, six months previously, proved too severe a shock which apparently hastened his death.

Dr Singh had a distinguished career in the University of Allahabad from where he took the M. Sc. degree in Botany in 1928 standing second in order of merit. He underwent a two years postgraduate training in Mycology and Plant Pathology at the Indian Agricultural Research Institute and was later appointed Research Mycologist at the Hill Fruit Research Station, Chaubattia, from 1934 to 1946. Dr Singh put himself whole-heartedly into the work and added considerably to our scanty knowledge of the diseases of fruit trees in Kumaon. He developed simple control measures which are now very popular in Kumaon hill tracts. In 1945, he was awarded the degree of Doctor of Philosophy by his alma mater in recognition of his work on the *Cercospora* diseases of pulses and diseases of fruits and fruit trees. In 1947, Dr Singh was appointed Plant Pathologist to the Government of the United Provinces of Agra and Oudh and had developed plans for intensive investigation of several cereal diseases that occur in the Province.

Dr Singh was a kind, sympathetic and sincere man who was loved by all with whom he came into contact. He had a profound interest in the sciences of Mycology and Plant Pathology and his knowledge of fruit diseases of U. P. was very deep. He leaves behind his wife, three young sons and a host of friends and colleagues to mourn his loss. To Mrs Singh on whose shoulders has fallen the care and bringing up of the children, we offer our heart-felt sympathies.

R. PRASADA

MORPHOLOGY AND CYTOLOGY OF ENTYLOMA MICROSPORUM (Unger) Schroet. AND UROCYSTIS ANEMONES (Pers.) Wint. ON RANUNCULUS REPENS L.

By M. C. DAS

(Accepted for publication April 4, 1949)

WHEREAS the morphology, cytology and genetics of many species of the *Ustilaginaceae* have been fully investigated, most species of the *Tilletiaceae* have been neglected in this respect. As some smuts included in the *Tilletiaceae* are of economic importance, a precise knowledge of the life histories will be of much importance in understanding the behaviour of the group. Through the researches of Fischer von Waldheim (1869), de Bary (1874), Schroeter (1877), Wolff (1873, 1874), Brefeld (1895) and some later workers, the life histories of some species of the *Tilletiaceae* are known, but in other species the germination of chlamydospores has still to be investigated.

In the genus *Entyloma*, de Bary (1874) first observed the germination of chlamydospores of a few species, which was later confirmed by Brefeld (1883) and others. In this genus germination of the chlamydospores of the following species is known :— *Entyloma antenariae* (Liro, 1904), *Entyloma aschersonii* (Woronin, 1882), *Entyloma calendulae* (de Bary, 1874 ; Paravicini, 1917 ; Stempell, 1934), *Entyloma chrysosplenii* (Maire, 1900), *Entyloma dahliae* (Pape, 1926), *Entyloma eryngii* (de Bary, 1874; Woronin, 1882), *E. fergussoni* (Kaiser, 1936), *Entyloma magnusii* (Woronin, 1882), *Entyloma microsporum* (De Bary, 1874), and *Entyloma ranunculi* (de Bary, 1874 ; Brefeld 1883 ; Ward, 1886 ; Kharbush, 1927 and others). But in most of the species nuclear details are lacking. To a certain extent, nuclear behaviour in *Entyloma ranunculi* has been investigated by Kharbush (1927) and Stempell (1934) and in *Entyloma calendulae* by Stempell (1934) and Paravicini (1917).

From the observations of the above authors, it can be gathered that in *Entyloma*, the mature chlamydospore germinates giving rise to a long or short promycelium, which at its tip bears a cluster of sporidia. These sporidia fuse in pairs, and from each pair of fused sporidia a secondary sporidium or a dicaryophytic hypha develops.

The sporiferous hyphae become swollen at intervals or at the ends of the branches. These swollen cells contain two nuclei. As these swellings increase in size the nuclei approach one another and fuse, giving rise to young chlamydospores. The mature chlamydospore acquires a double wall which is thick and smooth. These chlamydospores are embedded singly in the host tissue.

In the genus *Urocystis* germination of the chlamydospores of the following species is recorded :—*Urocystis anemones* on *Ranunculus sardous* (Brefeld, 1895), on *Anemone nemorosa*, *Ranunculus repens* and *R. bulbosus* (Plowright, 1889), on species of *Anemone* and *Ranunculus* (Schellenberg, 1911), on *Anemone nemorosa* (Paravicini, 1917), on *Ranunculus repens* (Kniep, 1921)), (as *Urocystis ranunculi* on *Anemone nemorosa*) (Brefeld, 1912), as *Urocystis pompholygodes* on the species of *Ranunculus* (Fischer von Waldheim, 1869)) ; *Urocystis occulta* (Kühn, 1858 ; Wolff, 1873, 1874 ; Brefeld, 1895 ; McAlpine, 1910 and Stakman, 1934), *Urocystis cepulae* (Thaxter, 1889 : Anderson, 1912 ; Blizzard, 1926) ; *Urocystis filipendulae* (Brefeld, 1895), *Urocystis fischeri* (Plowright, 1889), *Urocystie violae* (Kühn, 1876 ; Prillieux, 1880 ; Brefeld, 1895 ; Paravicini, 1917 ; Rawitscher, 1922), *Urocystis hypoxyis* (Thaxter, 1889), *U. tritici* (McAlpine, 1910 ; Noble, 1923 ; Cunningham, 1924 and Griffiths, 1924). The nuclear condition and chlamydospore development

in the host plants have been described for the following species:—*Urocystis occulta* by Kühn (1858), Wolff (1873) and Stakman (1934); *Urocystis colchici* by Winter (1876); *Urocystis violae* by Prillieux (1880), Dangeard (1894), Paravicini (1917) and Rawitscher (1922); *Urocystis cepulae* by Thaxter (1889), Whitehead (1921), Anderson (1921) and Blizzard (1926); *Urocystis anemones* on *Anemone nemorosa* by Paravicini (1917), on *Anemone acutifolia* by Lutman (1910) and on *Ranunculus acris* by Wang (1934)'.

From the studies of the above authors, the life cycle of *Urocystis* can be represented in the following manner :—The mature chlamydospore on germination gives rise to a long or short promycelium, at the tip of which sporidia are developed. During the time of germination the diploid nucleus undergoes divisions giving rise to a number of haploid nuclei. These nuclei travel to the sporidia, which then fuse in pairs. The nucleus of one of the fusing pair of sporidia migrates into the other giving rise to a bi-nucleate sporidium, which in turn germinates immediately, giving rise to a bi-nucleate hypha. The parasitic mycelium is bi-nucleate and sometimes pluri-nucleate. At the time of spore formation the hyphae branch and the end cells of the branches, which contain two nuclei, begin to swell. Nuclear fusion follows giving rise to young chlamydospores. During the formation of these spores, they group together into a somewhat compact ball. In the spore ball some spores develop to maturity, while in others the cell contents disappear and these become sterile spores. These sterile spores remain attached to the fertile ones by their gelatinous walls. The chlamydospores acquire a double wall which is smooth.

Urocystis cepulae, investigated by Blizzard (1926), presents a different picture. Blizzard states that on germination, the chlamydospore of *Urocystis cepulae* produces a hemispherical promycelium which gives rise to eight or fewer hyphae. These primary hyphae grow and branch. Sporidia are not formed, nor does conjugation take place between the promycelial branches. The parasitic mycelium is uni-nucleate throughout the vegetative period, but at the time of spore formation the hyphae become bi-nucleate.

Although the germination of the chlamydospores of *Entyloma microsporum* was studied by de Bary, the nuclear details are lacking. The life history and nuclear details of *Urocystis anemones* on *Anemone nemorosa*, investigated by Paravicini, differ from that on *Ranunculus repens* studied by Kniep (1921). There is no record of the mode of development of chlamydospores of *Urocystis anemones* on *Ranunculus repens*. The present studies were undertaken with a view to finding out the morphological and cytological details of these two species of the *Tilletiaceae*.

MATERIAL AND METHODS

Specimens of *Ranunculus repens* infested with *Entyloma microsporum* and *Urocystis anemones* were collected from the banks of Skollie Burn and other places at Loganlea, a village about 20 miles south west of Edinburgh. Mature chlamydospores were allowed to germinate in plain water, and 2 per cent malt agar, spread on slides in thin films according to the methods used by Wang (1934, 1943), and Hirschhorn (1945). When the desired stages were reached, the material was killed and fixed in Flemming's weak solution or Karpechenko's fixative. The material fixed in Flemming's solution was bleached with 10 per cent H_2O_2 for about 30 minutes and was then stained with Flemming's triple stain or iron-alum-haematoxylin.

To study the nuclear condition and spore development inside the host, infected leaves, petioles and stems, at various stages of development of the parasite, were

fixed in Flemming's weak solution. Microtome sections 6 to 12μ thick were bleached with 10 per cent H_2O_2 for 8 to 10 hours before staining. The following stains were used, employing standard techniques.

1. Bismarck brown-gentian violet followed by Gram's iodine
2. Flemming's triple stain
3. Iron-alum-haematoxylin

Flemming's triple stain and iron-alum-haematoxylin yielded the best results as far as nuclear details were concerned.

ENTYLOMA MICROSPORUM ON RANUNCULUS REPENS L.

MORPHOLOGY:—Leaves of *Ranunculus repens* attacked by *Entyloma microsporum* show a diseased appearance. Pustules usually occur abundantly on the upper surface of the leaves, occasionally on the petioles and rarely on the lower surface. They are confined to the areas between the veins. Often the infected leaf on which only one or two pustules are found presents a more or less healthy appearance except for these specks. On the lamina the pustules are round or slightly oval, about 1–3 mm. in diameter, and one to several of them may be seen. The pustules at first appear as shining white spots. As they mature and grow older, they turn pale yellowish and later yellowish brown. Usually they are hemispherical, but often concavo-convex, shiny and hard. These pustules are filled with hyaline or slightly yellowish brown chlamydospores (Fig. 1) These spores are spherical to elliptical, often polyhedral, with thick hyaline smooth epispore. Spores measure 12–16 x 14–18μ in diameter including the epispore. Conidia are not known in this species. *Entyloma microsporum* sometimes occurs on the same host plant as *Urocystis anemones*.

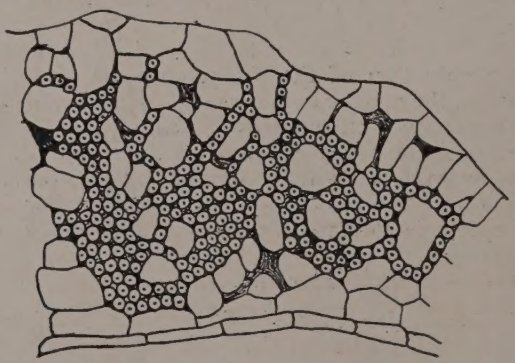


Fig. 1. See text for explanation

CYTOLOGY:—Chlamydospores from mature sori gave about 50 per cent germination in water and on plain agar and 2 per cent malt agar within 48 hours. They are capable of immediate germination without a dormant period. On germination the promycelium pushes out of the spore through the epispore (Fig. 4). It is usually an unbranched tube of variable length possessing a width of 3-5μ. De Bary (1874) first observed the germination of the spores and stated that the length of the promycelium was about 4 to 10 times the diameter of the spore. In the present investigation also the lengths of the promycelia are found to be variable, sometimes short, sometimes very long, up to 80μ. From the observations made in connection with

the nuclear divisions in this smut, as well as in *Urocystis anemones*, it may be concluded that the increase in length of the promycelium has a certain relationship with the division of the diploid nucleus. The promycelium, whether short or long, produces at its tip 4 to 8 primary sporidia (Figs. 5, 13, 14, 15, 16, 17). As de Bary noted, in certain cases, however, the promycelium continues to grow and then branches, giving rise to a number of uni-or bi-nucleate hyphae. Sometimes the promycelium is septate, having 3 or 4 cells each of which contains one or two nuclei. Later these cells produce long conidia-like structures or hyphae. Occasionally the promycelium grows to a certain length and then bifurcates giving rise to two hyphae each of which receives two nuclei from the promycelium. During the growth of the promycelium the protoplasm has a tendency to move forward towards the tip leaving behind it an empty space, which is often septate.

The primary sporidia, produced at the tip of the promycelium, are generally oval (Fig. 15, 16), but sometimes have a different shape, being long and more or less acicular (Fig. 5, 17). These acicular sporidia often have short stalks and are nearly double the length of the oval-shaped ones. Forms intermediate between these two extremes can be found. Usually only one type of sporidia is developed on each promycelium.

A mature chlamydospore like other smut spores contains a diploid nucleus which is fairly large. In a resting condition this nucleus contains one nucleolus, and is surrounded by a nuclear membrane (Fig. 2). The chromatic substance in the nucleoplasm is always deeply stained. With the onset of germination, nuclear changes take place within the spore, resulting in the divisions of the diploid nucleus, but due to the thickness of the epispore it has not been possible to discern the details of the divisions. At a slightly later stage, 2, sometimes 4, dark-staining bodies can be seen inside the spore (Figs. 3, 4). Presumably these are the daughter nuclei formed after the divisions of the diploid nucleus inside the spore. These nuclear changes take place before, during, or after the emergence of the promycelium from the spore. These nuclei migrate into the promycelium during its development and ultimately into the primary sporidia which are developed at the tip of the promycelium. These primary sporidia are then cut off by basal septa at their bases. Usually one haploid nucleus migrates to each sporidium. Migration of the nuclei to the sporidia is not simultaneous, some may migrate at an early stage while others may enter after some time. Fusion of sporidia and movement of one nucleus from one sporidium to the other, in a fused pair, is completed before other nuclei in the promycelium show any sign of migration to the other sporidia (Fig. 5, 14). Usually the number of nuclei corresponds to the number of sporidia, but often the number of the former is greater than the latter. Entry of two nuclei to one primary sporidium has not been observed. The additional nuclei remain in the promycelium (Fig. 13). When the divisions of the diploid nucleus are completed within the spore, resulting in the production of haploid nuclei, the promycelium after a short period of growth, produces sporidia at its tip (Figs. 5, 14, 15). Sometimes however, the diploid nucleus migrates to the promycelium (Fig. 11), where it completes its first and subsequent divisions.

The diploid nucleus when it divides for the first time in the promycelium, is resolved into 4 chromosomes (Figs. 6, 7). These 4 chromosomes then divide mitotically into two groups, each group containing 4 chromosomes (Figs. 8, 9). It has been observed that in a large number of cases the first division of the diploid nucleus, especially when it divides in the promycelium, is an equational one. In this division even the achromatic spindle is visible (Fig. 8). In the telophase these two groups

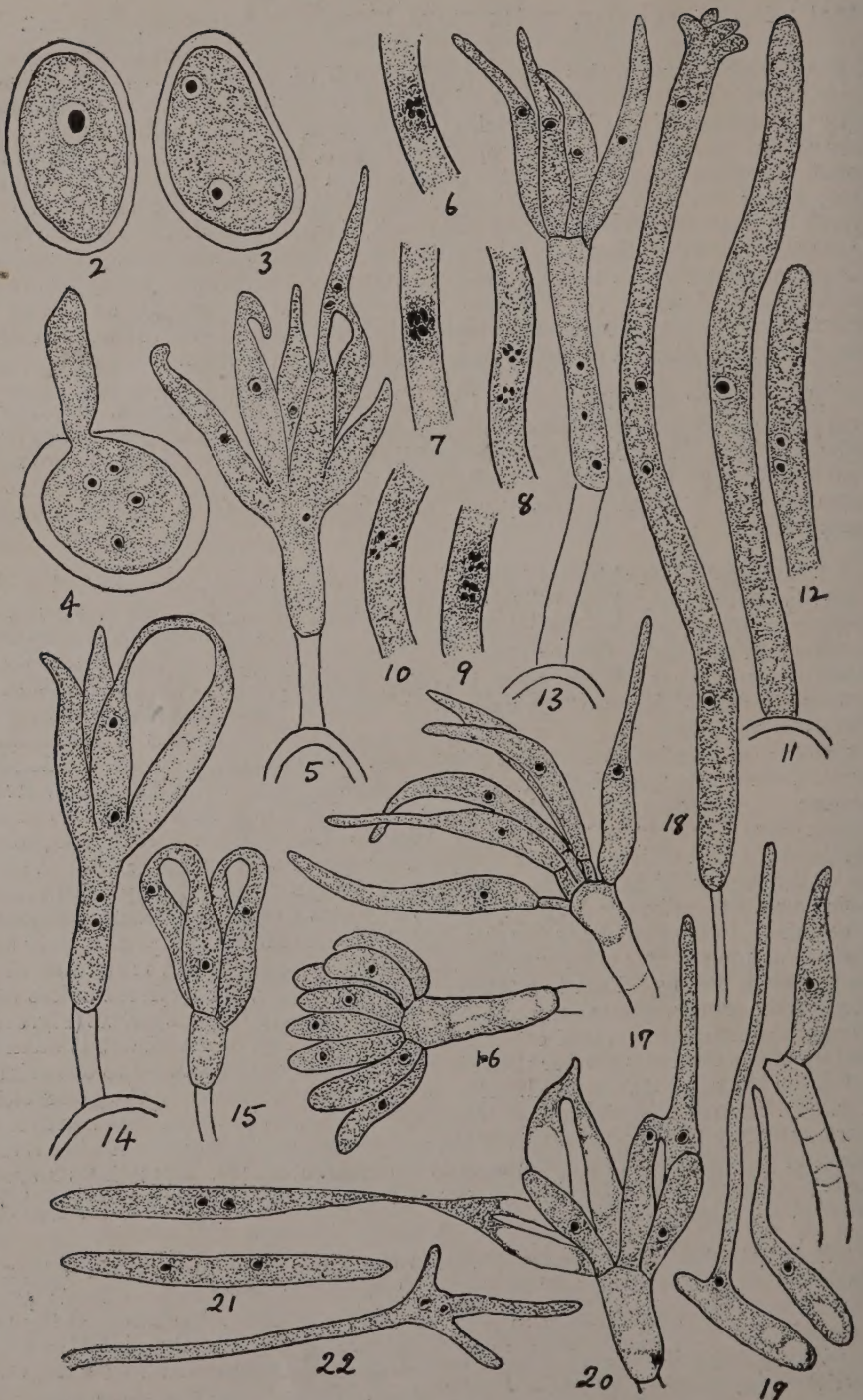


Fig. 2 to 22. Entlyoma microsporum. See text for explanation

of 4 chromosomes soon unite, the spindle is withdrawn, and two daughter nucle are formed (Fig. 12). These two daughter nuclei each soon divide simultaneously or successively into two groups of two chromosomes (Fig. 10). Evidently this second division of the diploid nucleus is a reductional one, as a result of which 4 haploid nuclei are formed. Sometimes further mitotic division follows resulting in the production of 5 to 8 haploid nuclei. The promycelium keeps on growing while these nuclear changes are taking place within it till the last generation of haploid nuclei has been formed. As soon as the divisions of the diploid nucleus are completed, small protuberances begin to appear at the tip of the promycelium (Fig. 18). These outgrowths then increase in size and, at the same time, the haploid nuclei begin to move towards them. As the protuberances grow, developing into primary sporidia, the haploid nuclei enter at some stage, probably at a later phase of maturation. After the migration of the haploid nuclei into the sporidia, septa are developed at the bases of the latter cutting them off from the rest of the promycelium. From the mode of growth of the sporidia at the tip of the promycelium and of the promycelium itself, while nuclear divisions are taking place inside it, it can be concluded that there is a distinct relationship between the nuclear divisious and the development of the sporidia. That is, the sporidia are not developed until the nuclear divisions are completed.

After the migration of the haploid nuclei, the sporidia begin to fuse in pairs. Usually the tips of the sporidia elongate slightly and then bend sideways or downwards as though there was a force of attraction between them (Fig. 5). When two such bent tips meet, fusion follows, resulting in a curved conjugating tube (Figs. 14, 15). Through this conjugation tube, the nucleus of one sporidium passes into the other giving rise to a bi-nucleate sporidium (Fig. 14). At the junction of the two projecting tubes, a small tube sometimes grows out, into which both the nuclei of the fusing pair migrate (Fig. 5). Often, however, the fusion between two sporidia is accomplished by a conjugation bridge developed near the tips or bases of the sporidia. Through this bridge the nucleus of one sporidium passes into the other, giving rise to a bi-nucleate sporidium. Another noteworthy point in connection with the fusion between these sporidia is that often as soon as the conjugation bridge is established between the two sporidia and the two protoplasts are connected, one of the sporidia immediately begins to grow even before the actual migration of the nucleus of the other sporidium into it. This fact clearly indicates that the sporidium which grows has received some stimulus from the other sporidium immediately after the union of two protoplasts through the conjugation bridge. The bi-nucleate sporidia germinate directly giving rise to secondary bi-nucleate sporidia or bi-nucleate hyphae (Figs. 20, 21, 22). The bi-nucleate hyphae grow and branch and the nuclei divide, supplying nuclei to the branches (Fig. 22). The bi-nucleate secondary sporidia, which have been developed from the primary bi-nucleate sporidia, also germinate giving rise to bi-nucleate hyphae, which then branch. The nuclei divide and the hyphae become multi-nucleate.

Occasionally the primary sporidia, instead of fusing, become detached from the promycelium and germinate directly, giving rise to uni-nucleate hyphae (Fig. 19). These uni-nucleate hyphae grow for a time and then branch. The nucleus divides and furnishes nuclei to the branches.

Study of the Fungus in the Host Plant

Sections through the pustules at different stages of development of the fungus reveal that in the old pustules the chlamydospores are already formed while in the young ones the chlamydospores are still in the process of formation. In still younger

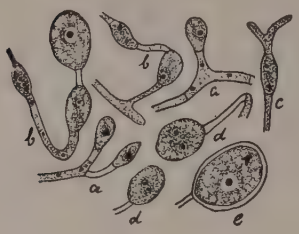


Fig. 23

See text for explanation

ones, the hyphae are just beginning to form chlamydospores. In the area of a young pustule, one can clearly follow the course of the hyphae. They often grow in parallel bundles, but are less compact than those of *Urocystis anemones*. While occupying the inter-cellular spaces they often intertwine. These vegetative hyphae are septate and irregularly branched. The mycelial cells are 6-8 μ long and 1-2 μ broad. The hyphae are mainly inter-cellular. As the hyphae push along the inter-cellular spaces, the host cells fall wide apart. No haustoria could be observed.

In a preparation in which one can follow a hypha or an entire branch, it can easily be recognised that the cells are mostly bi-nucleate though in certain cells the number of nuclei is more than two. Sometimes these nuclei occur in pairs, while at others they are irregularly dispersed inside the hyphal cells. These nuclei are small, and are surrounded by a clear zone. The cytoplasm is dense and homogeneous in young cells, but as the cells grow, one to many vacuoles appear in them. Small spherical granules, which are stained black by haematoxylin, may also be seen.

Development of Chlamydospores in the Host Plant

At the time of spore formation, the hyphal cells begin to swell, sometimes at the end of a branch (Fig. 23*a*) or a row of cells towards the end of a branch (Fig. 23*b*), or some cells along the length of the hypha (Fig. 23*c*). These swellings are cut off by septa from the rest of the hyphae. As they grow, they begin to round off. These swellings contain two nuclei each, which may lie side by side or may occupy any position inside the cell. As the swellings enlarge and round off, the nuclei begin to approach one another and finally fuse. Fusion of the nuclei may take place even when the spores are quite young (Fig. 23*a*) or at any stage during the development of the spores up to the size of about $\frac{1}{3}$ of the mature chlamydospores (Fig. 23*d*). The fusion nucleus is quite large and is always surrounded by a clear zone. Development of chlamydospores in the same hypha or in the same inter-cellular space is not simultaneous. In the same hypha one can see several young spores in various stages of development, in some nuclear fusion having already taken place, while in others the fusion is about to take place, or the nuclei are apart. As the spores swell and enlarge they are connected to the mother hypha by empty and dead pieces of hyphal cells.

The diploid nucleus may occupy any position in the spore. It is large with a dark-staining prominent nucleolus, and is surrounded by a fine nuclear membrane. The spores of this fungus acquire a double wall (Fig. 23*a*). Usually the outer

membrane is thick and hyaline. The mature spores are all free, and are distributed irregularly in the inter-cellular spaces (Fig. 1). They are nearly hyaline wiht a slight tint of pale yellowish brown colour.

Pathological Modifications of the Host Tissues

The infected tissues of the leaf do not show any differentiation into palisade and spongy parenchyma. Between the upper and lower epidermis 6 to 10 layers of parenchymatous cells could be seen which show hypertrophy. Sometimes the epidermal cells also lose their identity. These cells are much larger than the other cells of the normal leaf (Fig. 1). As a result of the hypertrophic condition of the cells, the pustules present a swollen appearance on the outer surface of the leaf.

As the hyphae push along the inter-cellular spaces, the cells of the infected organ fall apart, making more room for the parasite. Pathological modifications of the infected cells are revealed by the changes brought about in the nuclei, chloroplasts, and cytoplasm of the infected host cells. The nucleus becomes pale and sometimes deeply stained. One cannot distinguish the nuclear membrane, nucleoplasm or the nucleoli. Gradually the contour of the nucleus becomes irregular and finally it breaks up into chromatin masses. The chloroplasts are large in healthy cells, but in the infected cells they change. The colour fades away, and their size diminishes, until they finally disappear. Cytoplasm of the infected cells also show a marked change, it becomes more coarse and granular, and gradually breaks up into irregular masses of *chromatin* substance, *which are finally ingested by the parasite.* Similar modifications of the host cells can be noticed in the places where the parasite is intra-cellular. As the fungus makes its further progress, the walls of these infected cells break up, and more space is provided for the parasite.

The vascular tissue is not hypertrophied and not chlamydospores are formed in it.

UROCYSTIS ANEMONES ON RANUNCULUS REPENS

MORPHOLOGY.—This is the most common *Urocystis* found to occur on the species of *Ranunculus* and *Anemone.*

The sori are easily recognised on the leaves, petioles and stems, forming very conspicuous pustules of varying size and shape. While young they look whitish, but as they grow, they become yellowish brown and finally black. Upon rupture these pustules disclose a dusty brown-black spore mass, consisting of irregular spore balls. Each spore ball consists of one to a few fertile spores, incompletely covered by a few sterile cells. Occasionally, however, a single spore may be seen without any cover of sterile cells. The spores are dark brown, oblong or ovoid to polyhedral or subspherical. The epispore is somewhat thick and smooth. The spores measure 9-14μ X 12-18μ and the sterile spores measure 6-10μ X 8-13μ. The sterile spores are hyaline with smooth walls.

The presence of the parasite causes hypertrophy and deformities of the leaves, petioles and stems. When the spores mature, the tissues of the infected plant disrupt, releasing the chlamydospores.

CYTOLOGY.—Under ordinary conditions, the chlamydospores are capable of germinating without dormancy. Mature healthy spores collected from the pustules germinated within 48 hours in water, plain agar, and 2 per cent malt agar. On germination, a promycelium which is usually short and thick, emerges from each

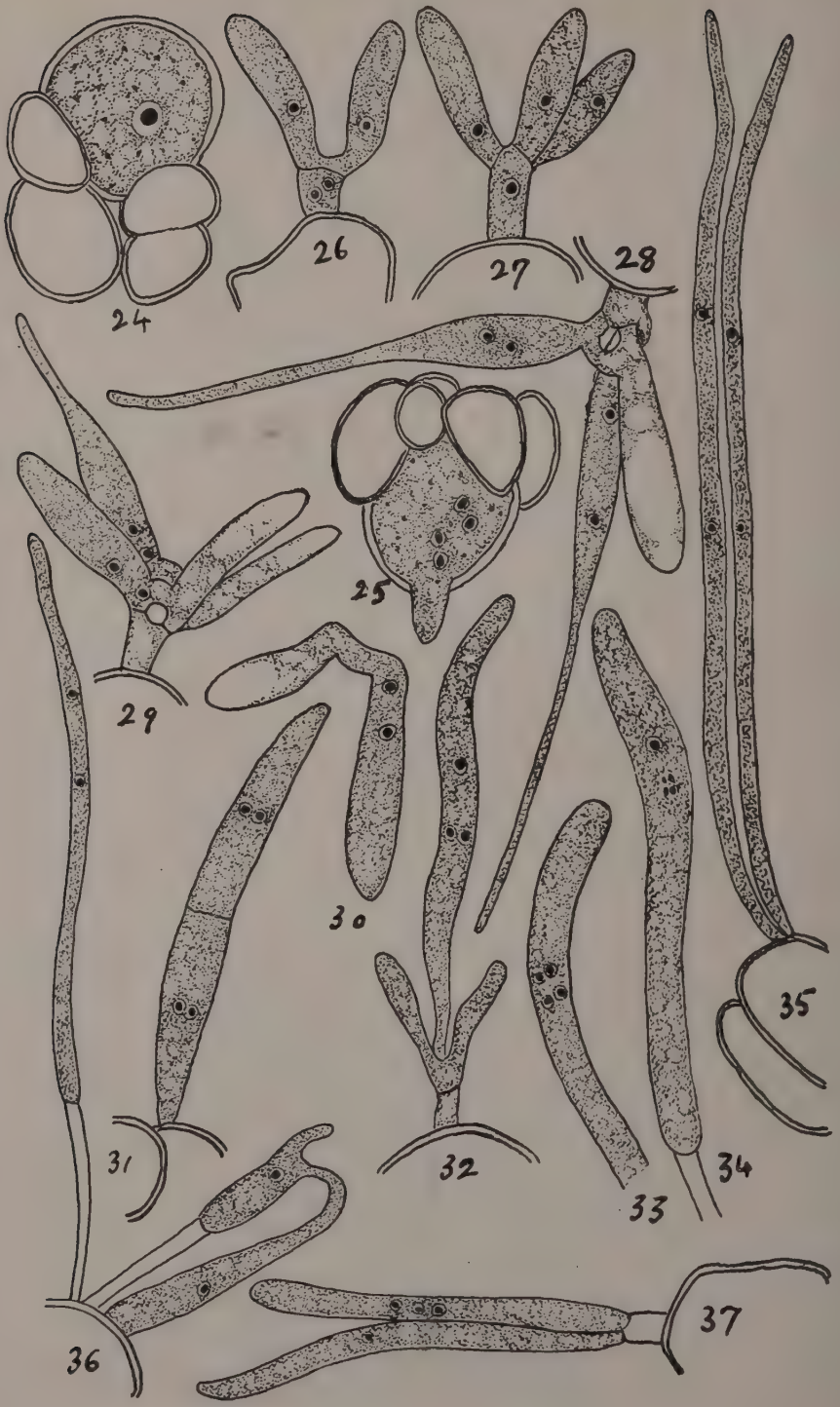


Fig. 24 to 37. *Urocystis anemones*. See text for explanation

spore through a gap in the spore wall. This promycelium after a short time produces at its tip a cluster of sporidia (Figs. 26, 27, 29). The number of these primary sporidia varies from 2 to 4.

The mature chlamydospores of *Urocystis anemones* contain a diploid nucleus (Fig. 24), which is fairly large and surrounded by a clear zone. On germination this diploid nucleus divides, and usually both the divisions are completed inside the spore. Sometimes the diploid nucleus migrates into the promycelium and completes all the divisions inside it. In such cases the promycelium continues to grow and elongate untill all the nuclear divisions are completed. As a result of both the divisions of the diploid nucleus inside the spore, 4 haploid nuclei are formed (Fig. 25), and as soon as the primary sporidia are developed at the tip of the promycelium, these nuclei migrate into them.

When there are two such sporidia produced at the tip of the promycelium, two haploid nuclei, presumably of opposite sex, migrate to each one of them, which are then cut off by basal septa. After receiving the nuclei, the sporidia begin to grow as bi-nucleate hyphae (Fig. 35). Often however, each sporidium receives only one nucleus, and the remaining two may stay either inside the spore or in the promycelium (Fig. 26). Sometimes three haploid nuclei migrate into one sporidium, and the fourth one passes to the other sporidium (Fig. 37). When there are three such sporidia produced, three haploid nuclei pass to them, the fourth one remaining in the promycelium (Fig. 27). If 4 sporidia are developed, then the haploid nuclei are equally distributed, each sporidium receiving only one.

Usually the conjugation between the sporidia is effected by the formation of a conjugation tube at the base of the sporidia (Fig. 28, 29), but often the conjugation tube is developed at the apical ends (Fig. 36). The nucleus and contents of one sporidium passes into the other sporidium through this conjugating tube (Figs. 29, 30). The conjugation between the third sporidium and the promycelium also takes place in the same way by the formation of a conjugating tube. The nucleus from the promycelium migrates to the third sporidium through this conjugating tube, giving rise to a bi-nucleate sporidium which soon begins to grow as a bi-nucleate hypha (Fig. 28). Observations made here in connection with the migration of the nucleus from the promycelium to the third sporidium through the conjugation tube agree with those of Kniep (1921). The nucleus from the promycelium always goes to the sporidium, but not *vice versa*. Sometimes however, no conjugation tube is formed between the third sporidium and the promycelium, the two nuclei directly migrate to the third sporidium, which then continues to grow as a bi-nucleate hypha.

Sometimes three haploid nuclei go to one sporidium, and the fourth one goes to the second sporidium, while the third sporidium receives no nucleus. A still more marked irregular distribution of nuclei can be observed, when both the daughter nuclei, after the first division inside the spore, migrate to the third sporidium, while the other two sporidia remain empty. Inside the third sporidium these two nuclei divide successively or simultaneously, giving rise to a 3-or 4-nucleate condition of the sporidium (Fig. 32). At the same time this sporidium continues to grow and elongate, while the other two non-nucleate sporidia remain short.

According to Paravicini (1917), often the promycelium of the germinating spore is made up of several uni-nucleate cells, and the dicaryophase arises from the fusion of the neighbouring cells. In the present investigation also, a few instances have been noted where the promycelium is made up of two cells, each of which contains a

pair of nuclei (Fig. 31), but no fusion between the neighbouring cells has been observed. Sometimes the diploid nucleus migrates to the promycelium where it completes all the divisions. In such cases the promycelium instead of producing sporidia at the tip, continues to grow till the divisions are completed. In the promycelium, the diploid nucleus divides giving rise to two daughter nuclei, which soon divide simultaneously or successively giving rise to four haploid nuclei (Fig. 33). Unfortunately, the details of the first division of the diploid nucleus were not clearly observed, but when the daughter nuclei divide, it has been observed that each of them resolved into four chromosomes which separate into two groups, each group containing two chromosomes (Fig. 34). From this it may be inferred that the first division of the diploid nucleus is equational and the second division is reductional, and the haploid number of chromosomes is 2 and the diploid number is 4. After the formation of the haploid nuclei, the sporidia start to develop at the tip of the promycelium. The haploid nuclei enter the sporidia at some stage during the development of the latter. After the migration of the haploid nuclei the sporidia are cut off by basal septa and fusion follows. The nucleus of one of the fusing pair of sporidia passes to the other giving rise to a bi-nucleate sporidium (Fig. 29, 30).

The bi-nucleate sporidium immediately after the initiation of the bi-nucleate condition begins to grow into a bi-nucleate hypha. This bi-nucleate hypha continues to grow and branch, the nuclei divide simultaneously or successively, producing nuclei some of which pass into the branches. Sometimes immediately after the establishment of the conjugation tube between two sporidia, one of them begins to grow into a long hpyha, into which contents of both the sporidia migrate. The hyphae in culture are aseptate and contain one, two or more nuclei. No chlamydospores have been obtained in culture.

STUDY OF THE FUNGUS IN THE HOST TISSUE

Sections of the infected leaves, petioles and stems show the presence of abundant mycelium in the intercellular spaces. The hyphae are often arranged in more or less compact bundles, frequently intertwining in their course. They are directed following the longitudinal axis of the infected organs. The hyphae, as noted by Lutman (1910) and Wang (1934) are mostly intercellular, but often they enter and pass through the host cells. Haustoria are abundant in this species : they may be lateral or terminal. After penetrating the cell membrane, the fungal filaments swell and branch out in various ways, forming absorbent knob like structures, or similar knob-like structures develop from the lateral wall of the fungus, where it comes into contact with the host cell.

The vegetative hyphae are septate and branched. Some hyphal cells are fairly long while others are short. The protoplasm is homogeneous and often vacuolated. Usually the hyphal cells contain two nuclei, but some, especially the long cells, contain more than two nuclei. These nuclei are very small and are surrounded by a clear zone. They may lie in pairs inside the cell or may occupy any position.

Seyfert (1927) has demonstrated that anastomoses take place between adjacent cells of the hyphae in *Urocystis anemones*. But in the present study no such anastomoses could be observed in any of the preparations. Wang (1934) also did not see any anastomoses in the hyphae of this species in the infected tissues of the host plant.

DEVELOPMENT OF CHLAMYDOPSPORES IN THE HOST PLANT

Paravicini (1917), Lutman (1910) and Wang (1934) have studied the development of chlamydospores in *Urocystis anemones* on the hosts of *Anemone nemorosa*, *Anemone acutiloba* and *Ranunculus acris* respectively. According to Lutman, the spores originate as short side branches containing two nuclei in a very dense cytoplasm. The side branches increase in length and size, and cut off new cells so that a chain of bi-nucleate cells is produced. The individual branch winds around itself or other branches and becomes contorted so as to become a part of the spore ball, which is composed of numerous small bi-nucleate cells. The central cells of the spore balls are transformed into fertile spores, while the peripheral ones lose their contents and become the sterile spores. Wang (1934) described a similar mode of development of chlamydospores in *Urocystis anemones* and stated that the cells of the spore ball are frequently bi-nucleate and rarely uni-nucleate. Besides this mode of development of spore balls, Wang observed sporiferous hyphae, whose contents accumulate and separate into fairly swollen cells, leaving empty spaces, and also other hyphae which segment directly into small irregular cells apparently independent of each other. The hyphae do not curl up and the sterile cells simply adhere to the fertile ones due to the gelatinous nature of the membrane of the latter.

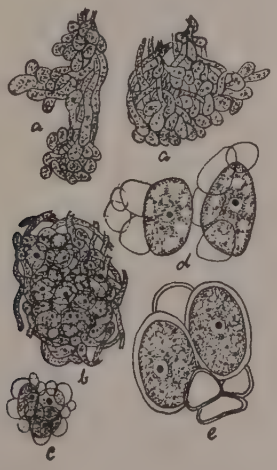


Fig. 38

See text for explanation

In the present investigation, the mode of development of the spores more or less corresponds to the description of Lutman. The bundle of hyphae destined to form spores, begins to coil, branch, curl and twist, especially at the ends (Fig. 38*a*). The cells at the tips of the hyphae are bi-nucleate. Sometimes one can follow an individual hypha up to the length of about 3 to 4 cells, just at the beginning of the formation of the spore knot. At slightly later stage coiling, curling and twisting in the formation of a spore ball become so pronounced that it is impossible to trace out the individual hypha. One can only see a knot consisting of long or short hyphal

cells, interwoven, surrounded and intertwined by hyphae. At this stage, as far as can be seen, all the cells are bi-nucleate. Gradually the cells of the spore ball begin to increase in size and become round. During the process of enlargement of these cells, the nuclei approach one another and fuse. In fact, there is no fixed time or place for the nuclear fusion. Nuclear fusion may take place in the cells when they just form the knot or up to the stage when they are about $\frac{1}{4}$ of the mature size. It was not possible to distinguish between the fertile cells and the sterile ones in the spore ball at the early stage, one can see only young spores of various sizes and shapes with one or two nuclei.

During the course of development and maturation of these young spores, certain cells, in which the nuclear fusion has already been effected, begin to enlarge. Nuclei in them become more prominent, the cytoplasm assumes a more granular appearance with the accumulation of droplets of oil (Figs. 38*c*, 38*e*, 38*d*). These spores develop to maturity, while some other cells, in which nuclear fusion may or may not have been effected cease at various stages to enlarge and develop. These cells become pale, gradually lose their contents, and finally become empty, and transformed into sterile cells. As these cells stop growth and development at various stages of maturation, one can see also sterile spores of various sizes—from very small ones to ones almost as big as the mature ones. Due to the gelatinous nature of the walls the sterile cells are attached to the fertile ones.

As the fertile spores enlarge they acquire a double wall which is fairly thick. In a fully matured spore, one can see a large diploid nucleus, surrounded by a nuclear membrane. The nucleus contains a nucleolus which stains more deeply than the chromatin substance in the nucleoplasm. The cytoplasm of the spore is homogeneous, and contains droplets of oil. At maturity the spore ball breaks up into smaller groups of spores, each containing one or a few fertile spores incompletely covered by one or a few sterile cells (Fig. 38*e*).

PATHOLOGICAL HISTOLOGY OF THE HOST TISSUE

A healthy, normal leaf of *Ranunculus repens* consists of an upper and a lower epidermis, a layer of palisade parenchyma and three or four layers of spongy parenchyma. Palisade and spongy parenchymatous cells contain numerous chloroplasts which are coloured deep grey by haematoxylin. The nucleus in the healthy and normal cell has a fairly round or elliptical contour and contains several deeply coloured nucleoli. Transverse sections of an infected leaf do not show any differentiation

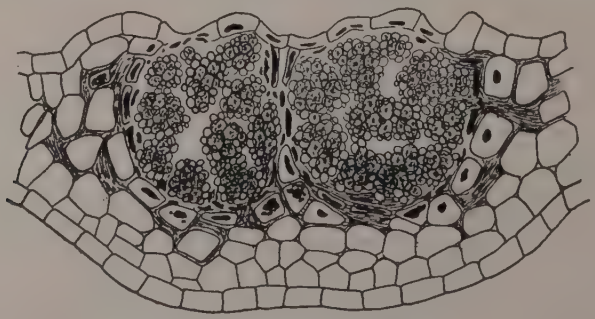


Fig. 39. See text for explanation

of leaf tissues. All the cells are more or less alike, and one can see about 8 to 12 layers of parenchymatous cells irregularly arranged between the upper and lower epidermis. These cells are much larger than the normal cells of the leaf. In between these cells the mycelium moves about in the inter-cellular spaces. Hypertrophy of the part results from parasitization by the fungus and development of the pustules containing the chlamydospores (Fig. 39).

Before the final breakdown of the host cells, nuclear changes appear. The nucleus which stains deep grey with haematoxylin often becomes dull or dark, and one cannot distinguish the nucleoli. Gradually the nucleus loses its membrane, and finally breaks up into pieces. In the modified cells, the degeneration of the chloroplasts is indicated by fading of the colour and gradual diminution in size; finally they disappear. Sometimes the chloroplasts break up into small parts, which eventually disappear. As the hyphae grow and move in the intercellular spaces, the neighbouring infected cells are pushed apart, and finally the cellular wall gives away. Similar hypertrophic condition and degeneration of the host cells have been observed in the tissues of stems and petioles parasitized by this fungus.

Degeneration of the host tissue is more pronounced in the places where chlamydospores are formed. Pustules start as isolated, almost circular patches, gradually begin to increase in size as the spores grow and mature, fuse together (Fig. 39), and finally burst open through the epidermis, liberating the chlamydospores. There is no hypertrophy of the vascular tissue and no chlamydospores are formed in it.

DISCUSSION

It is well known that the classification of the *Ustilaginales* into *Ustilaginaceae* and *Tilletiaceae* is based on the manner of spore germination. The *Tilletiaceae* are characterised by the bearing of a cluster of sporidia at the tip of the promycelium. The germination of the chlamydospores of the species belonging to different genera in the *Tilletiaceae* usually show such a cluster. The number of sporidia varies in the same species, the usual number being 4 to 8, but it may range from 2 to 16. Sometimes the promycelium, instead of producing a cluster of sporidia at the tip, continues to grow, branches, and gives rise to hyphae which contain one to several nuclei. A notable example of this type is *Urocystis cepulae* in which Blizzard (1926) has shown that the promycelium grows directly into a number of hyphae, and there is no sporidial formation.

The two species of the *Tilletiaceae* studied here, morphologically and cytologically, show that on germination the chlamydospore gives rise to a promycelium which bears a cluster of sporidia at the tip. The growth of the promycelium varies according to the nature of the nuclear divisions. Some promycelia bear sporidia while they are very short, while others grow to different lengths before bearing sporidia. But sometimes the promycelia elongate, branch, and directly produce hyphae as noted by Paravicini (1917) in *Urocystis anemones* and de Bary (1874) in *Entyloma microsporum*.

Each chlamydospore of *Entyloma microsporum* and *Urocystis anemones* contains a diploid nucleus like the other smuts. At the time of germination, the behaviour of the diploid nucleus varies according to individual peculiarity. In *Entyloma microsporum* and in *Urocystis anemones*, like *Tilletia holci* (Das, 1948) and *Tilletia tritici* (Holton & Heald, 1941, and Wang, 1934), all the nuclear divisions of the diploid nucleus may take place inside the spore, or in the promycelium, with all possible intermediate stages. The promycelia go on elongating till the last generation of haploid nuclei is formed.

It is determined for the first time that in *Entyloma microsporum* and *Urocystis anemones* the haploid number of chromosomes is 2 and the diploid number is 4.

After the entry of the nuclei, conjugation between the primary sporidia follows, and as a result one of the sporidia of the conjugating pair becomes bi-nucleate. In *Entyloma microsporum* a primary bi-nucleate sporidium may give rise to a secondary bi-nucleate or a uni-nucleate sporidium, transmitting both or one of the nuclei. This mode of development of secondary sporidia is very common in *Tilletia holci* (Das, 1948) and *Tilletia tritici* (Wang, 1934). Often, however, the primary bi-nucleate sporidia germinate directly giving rise to hyphae. In *Urocystis anemones*, no secondary sporidia have been observed. The primary bi-nucleate sporidia germinate directly giving rise to dicaryotic hyphae.

The parasitic mycelium in both the species is mostly intercellular, irregularly branched and septate. Usually hyphal cells are bi-nucleate. Seyfert (1927) claimed to have observed the presence of filaments of anastomosis in the mycelium of *Urocystis anemones* and *Entyloma calendulae* and in a few other species of smuts. But according to Wang (1934) these are absent in *Urocystis anemones*. Observations made in the present investigation of *Entyloma microsporum* and *Urocystis anemones* do not indicate the presence of clamp connections.

The cytological phenomena in *Entyloma microsporum* resemble those described by Kharbush (1927) and Stempell (1934) for *Entyloma ranunculi* and by Paravicini (1917) for *Entyloma calendulae*. In *Urocystis anemones*, the nuclear behaviour and their associate phenomena are similar to those described by Kniep (1921) in the same species, and by Rawitscher (1922) for *Urocystis violae*, and Stakman (1934) for *Urocystis occulta*.

The various methods of fusion in the origin of the dicaryophase, indicate that there is a sexual process in both the species investigated here, although as in other smut fungi "sex is reduced to very simple terms" as Stakman and others (1934) say. Whenever two sporidia, each containing a haploid nucleus of opposite sex, are close together, they fuse, and their nuclei become paired. This phenomenon is clearly seen in the fusion of primary sporidia. Often the pairing of nuclei is accomplished by the direct passage of 2 haploid nuclei from the promycelium to the sporidium or to the branches of the promycelium. Sometimes the pairing of nuclei is effected by the fusion of two uni-nucleate hyphae.

There appears to be no doubt about the haploid nature of the nuclei in the sporidia, for the diploid nucleus divides by successive divisions, one of which is a reductional one, and as a result the haploid nuclei are formed. There exists clear affinity between certain haploid nuclei, resulting in their pairing as indicated by various methods of fusion between these haploid nuclei. The fact that two haploid nuclei associate and pair, suggests that they contain different factors for sex. Further, the bi-nucleate sporidia, after the fusion, germinate almost immediately giving rise to bi-nucleate hyphae, or one of the sporidia sends out a hypha as soon as the conjugation canal is established between two sporidia, uniting two protoplasts. This reaction is noticeable even before the actual migration of the nucleus.

The migration of one haploid nucleus from one sporidium to the other in a fusing pair, fusion of two uni-nucleate hyphae, the combined effect of two nuclei in initiating a vigorous growth even when they are distantly apart, are significant facts in the sexual act. Furthermore, the dicaryophytic condition of the parasitic hyphae and the act of fusion of the nuclei at the time of chlamydospore formation, yield sufficient proof of the sexual process in these species.

SUMMARY

1. *Entyloma microsporum* forms yellowish white to brownish yellow pustules on the leaves and sometimes on the petioles of *Ranunculus repens* causing hypertrophy of the infected organs. Spores are yellowish white with hyaline, smooth, thick wall.

2. *Urocystis anemones* develops deep brown to black loose sori on the leaves, petioles and often on the stems of *Ranunculus repens* causing hypertrophy of the infected organs. Spores are deep brown with smooth epispores and are surrounded by sterile accessory cells.

3. Mature chlamydospores of both the species contain a diploid nucleus.

4. Fresh mature spores are capable of germination within 48 hours in water, plain agar, and 2 per cent malt agar.

5. On germination, the chlamydospores of both the species put out long or short promycelia at the tips of which primary sporidia are developed. In *Entyloma microsporum* the number of sporidia varies from 4 to 8 and in *Urocystis anemones* from 2 to 4.

6. The diploid nucleus of the chlamydospore of both the species may complete all the divisions inside the spore or in the promycelium or in both.

7. Diploid number of chromosomes in both the species is 4 and the haploid number is 2.

8. Usually one haploid nucleus migrates to each sporidium.

9. Fusion between the primary sporidia is accomplished by a conjugating tube. The nucleus of one of the fusing pair passes to the other sporidium, giving rise to a bi-nucleate sporidium. In *Entyloma microsporum*, the primary bi-nucleate sporidia give rise to secondary bi-nucleate sporidia or dicaryophytic hyphae. But in *Urocystis anemones* the primary bi-nucleate sporidia always produce dicaryophytic hyphae.

10. The parasitic mycelium is irregularly branched and hyphal cells are mostly bi-nucleate.

11. At the time of chlamydospore development, cells of the sporiferous hyphae which are bi-nucleate swell up, forming blister-like swellings. Nuclear fusion takes place inside them and they are ultimately transformed into chlamydospores.

12. In *Entyloma microsporum* chlamydospores are formed singly, whereas in *Urocystis anemones* they are formed in spore balls ; at maturity the fertile spores are partially or wholly covered by sterile cells.

13. Hypertrophy of the infected tissues, accompanied by increase in number and size of the cells, is observed in the leaves, petioles and stems of *Ranunculus repens* infected by *Entyloma microsporum* and *Urocystis anemones*.

14. Infected host tissues, especially in the places where the parasites fructify, degenerate and finally disappear.

The writer wishes to acknowledge his great indebtedness to Dr. Malcolm Wilson, Reader in Mycology, University of Edinburgh, for his generous assistance and constant interest throughout the work. His thanks are also due to Mr Andrew

Angus for his help in collecting the materials and for helpful suggestions and advice.

Dept. of Mycology
University of Edinburgh

REFERENCES

Anderson, P.J., 1912 .. Development and pathogenesis of the onion smut fungi. *Tech. Bull. Mass. agric. Exp. Sta.* **4**: 99-133

Blizzard, A. W., 1926. .. The nuclear phenomena and life history of *Urocystis cepulae*. *Bull. Torrey. bot. Cl* **53** : 77-117

Brefeld, O., 1883. .. .. Die Brandpilze 1. (Untersuchungen aus dem Gesamtgebiete der Mykologie) **5** : 220

1895. .. .. Hemibasidii. Brandpilze 111. (Untersuchungen aus dem Gesamtgebiete der Mykologie) **12** : 99-236

1912. .. .. Die Brandpilze und die Brandkrankheiten. V. Mit auschlissenden Untersuchungen der niederen und höheren Pilze. (Untersuchungen aus dem Gesamtgebiete der Mykologie) **15**

Cunningham, G. H., 1924. The *Ustilagineae*, or "Smuts," of New Zealand. *Trans. and Proc. New Zealand Inst.* **55** : 424-427

Dangeard, P. A., 1894. .. La reproduction sexuelle de l' *Entyloma glaucii* (Dang.) *Le Botaniste*, **4** : 12-17

Das, M. C., 1948. .. .. Morphology and cytology of *Tilltia holici* on *Holcus mollis* L. *Indian Phytopathology in* : 165-181

De Bary, A. 1874... .. *Protomyces microsporus* und seine Verwandten. *Bot. Zeit.* **32** : 81-92 and 97-108

Fischer Von Waldheim, A. A., 1869. .. .. Beiträge zur Biologie und Entwickelungsgeschichte der *Ustilagineen*. *Pringsh. Jahrb. wiss. Bot.* **7** : 61-125

Griffiths, M.A., 1924. .. Experiments with flag smut of wheat and the casual fungus, *Urocystis tritici* Ecke. *J. agric. Res,*. **27** : 425-449

Hirschhorn, E., 1945. .. A cytological study of several smut fungi. *Mycologia* **37** : 217-235

Holton, C. S. & Heald, F. D., 1941. .. .. .. Bunt or stinking smut of wheat. (A world problem), 105-114. Burgess Publishing Co. Minneapolis

Kaiser, W., 1936. .. .. Zur Biologie und Entwicklungsgeschichte einiger *Entyloma* Arten. *Angew. Bot.*, **18** : 81-131.

Kharbush, S. S., 1927. .. Contribution à l'etude des Phénomenes sexuels chez les Ustilaginées. *Ann. Sci. nat. Bot. Serie X* **9** : 577-596

Kniep, H., 1921. .. .. Über *Urocystis anemones* (Pers.) Winter. *Zeit. Bot.* **13** : 289-311

Kühn, J., 1858. .. .. Die Krankheiten der Kulturgewächse etc. Berlin
— 1876. .. .. *Tilletia secalis*, eine Kornbrandform des Roggens. *Bot. Zeit* **34** : 470-472

Liro, J. I., 1904. .. .. Mykologische Mitteilungen 11-15. *Acta. Soc. F. F. Fennica*, **26** : No. 5

Lutman, B.F., 1910. .. Some contribution to the life histories and cytology of the smuts. *Trans. Wis. Acad. Sci. Arts. Lett.* **16** : 1191-1244

Maire, R., 1900. .. .. Quelques Urédinées et *Ustilaginĕen* nouvelles ou peu Conrues. *Bull Soc. Mycol. France*, **16** : 65-72

McAlpine, D., 1910. .. The smuts of Australia. Melbourne, 1910

Noble, R. J., 1923. .. Studies on *Urocystis tritici* Koern., the organism causing flag smut of wheat. *Phytopathology* **13** : 127-139

Pape, H., 1926. .. .. Eine für Deutschland neue Blattfleckenkrankheit der Dahlien. *Die Gartenwelt*, **30** : 632-634 and 666-667

Paravicini, E., 1917. .. Untersuchungen über das Verhalten der Zellkerne bei Fortpflanzung der Brandpilze. *Ann. Mycol*, **15** : 57-96

Plowright, C. B., 1889. .. A Monograph of the British *Uredineae* and *Ustilagineae* etc. London

Prillieux, E., 1890. .. Quelques observations sur la formation et la germination des spores des *Urocystis* (*Ustilagineen*). *Ann. Sc. nat. Bot.* VI. **10** : 49-61

Rawitscher, F., 1922. .. Beiträge zur Kenntnis der *Ustilagineen* 11. *Zeit. Bot.* **14** : 273-296

Schellenberg, H. C., 1911. Die Brandpilze der Schweiz. *Beitr. Kryptogamenfl. Schweize*, **3** : 11

Schroeter, J., 1877. .. Bemerkungen und Beobachtungen über einige *Ustilagineen* (Cohn). *Beitr. Biol. Pflanzen*, **2** : 349-385

Seyfert, R., 1927. .. .. Über Schnallenbildung im Paarkernmyzel der' Brandpilze. *Zeit. Bot.*, **91** : 577-601

Stakman, E. C., and Cassel, R. C., Moore, M. B., 1934. The cytology of *Urocystis occulta*. *Phytopathology* **24** : 874-889

Stempell, K.L., 1934. .. Studien über die Entwicklungsgeschichte einiger *Entyloma* Arten und über die systematische Stellung der Familie der *Sporobolomycetes*. *Zeit. Bot.* **28** : 225-259

Thaxter, R., 1889 .. .. On certain fungus diseases of onion (*Allium cepa*). *Ann. Rep. Conn. agric. Exp. Sta.*, 129-154

Wang, C.S., 1943. .. Studies on cytology of *Ustilago cramsri*. *Phytopathology* **33** : 1122-1133

Wang, D. T., 1934. .. Contribution à l'étude des *Ustilaginees*. (Cytologie du parasite et pathologie de la cellule hóte). *Le Botaniste*, **26** : 539-670

Ward, H. M., 1886. .. On the structure and the life history of *Entyloma Ranunculi* (Bonord.) *Phil. Trans. Roy. Soc. London. B* **178** : 173-185

Whitehead, T., 1921. .. .. On the life history and morphology of *Urocystis cepulae*. *Trans. Brit. Mycol. Soc.* **7** : 65-71

Winter, G., 1876. .. .. Einige Notizen über die Familie der *Ustilagineen*. *Flora*. **59** : 145-152 and 161-172

Wolff, R., 1873. .. .. Beitrage zur Kenntniss der *Ustilagineen*. *Bot. Zeit*, **31** : 657-661, 673-677, 689-694

— 1874. .. .. Der Brand des Gestreides, Seine Ursachen und Seine Verhütung. Halle, 1-37

Woronin, M., 1882 .. Beiträge zur Kenntniss der Ustilagineen. *Abhand. Senckenberg. naturforch. Ges.* **12** : 559-591

All figures are drawn with camera lucida at x 3000.

Fig. 1. T. S. of leaf of *Ranunculus repens* infected by *Entyloma microsporum* showing the hypertrophic condition of the cells. The section is through a pustule which is filled with chlamydospores. Note also the bundles of hyphae in the inter-cellular spaces.

Entyloma microsporum

Fig. 2. mature chlamydospore with its diploid nucleus.

Fig. 3. Bi-nucleate stage inside the chlamydospore.

Fig. 4. 4-nucleate stage inside the spore, promycelium has already emerged through the spore-wall.

Fig. 5. Sporidia at the tip of the promycelium. In one pair conjugation has already taken place and in another case the elongation of the tip of the sporidium is bending towards another.

Fig. 6-7 Portions of two promycelia showing the resolution of the diploid nucleus into 4 chromosomes in each case.

Fig. 8. First equatiorial division of the diploid nucleus inside the promycelium, with 4 chromosomes in each group and on achromatic spindle.

Fig. 9. Two groups of 4 chromosomes, a stage either immediately after the first equatorial division of the diploid or at the beginning of the second reduction division.

Fig. 10. Bi-nucleate stage in the promycelium showing the reduction division of one nucleus; 2 chromosomes in each group with the achromatic spindle are visible.

Fig. 11. Single diploid nucleus in the promycelium.

Fig. 12. Bi-nucleate stage in the promycelium.

Fig. 13. 4 spordidia at the tip of the promycelium. Each sporidium has received one haploid nucleus and the remaining nuclei are left in the promycelium.

Fig. 14. Four sporidia at the tip of the promycelium ; in one pair conjugation has already been effected, while in the other pair the entry of the nuclei has not so far been effected.

Fig. 15. Conjugation between two pairs of sporidia.

Fig. 16. A whorl of short and oval-shaped sporidia.

Fig. 17. A whorl of long sporidia, some of which are stalked.

Fig. 18. Four nucleate stage in the promycelium. Note the protuberances at the tip of the promycelium.

Fig. 19. Direct germination into hyphae of sporidia which have not fused.

Fig. 20. Conjugation of primary uni-nucleate sporidia and development of bi-nucleate secondary sporidia.

Fig. 21. A bi-nucleate secondary sporidium.

Fig. 22. A portion of a bi-nucleate hypha which is branching.

Fig. 23. Different stages of development of chlamydospores. A, swollen end cells of branches of the hyphae in these nuclear fusion has already taken place ; b, rows of swollen cells along the length of the hyphae, in some cells nuclear fusion has already effected while in others nuclei are still apart ; e, another swollen cell in the middle part of the hypha ; d, enlarged cells showing delayed nuclear fusion ; e, matured chlamydospore after the formation of outer wall.

Urocystis anemones

Fig. 24. A mature chlamydospore with its diploid nucleus. Note the sterile cells surrounding the spore.

Fig. 25. Four-nucleate stage inside the spore, the promycelium has just emerged through the spore-wall.

Fig. 26. Two sporidia at the tip of the short promycelium ; each sporidium has received one nucleus while two nuclei are in the promycelium.

Fig. 27. Three sporidia each of which has received one nucleus from the promycelium while the fourth nucleus remained inside it.

Fig. 28. Conjugation between one pair of sporidia, as a result of which one sporidium has become bi-nucleate. Conjugation between the third sporidium and the promycellium has been effected by a short tube and the nucleus from the promycelium has migrated to the sporidium making it bi-nucleate.

Fig. 29. Conjugation between two pairs of sporidia.

Fig. 30. Conjugation between a pair of sporidia showing the migration of one nucleus from one sporidium to the other.

Fig. 31. Two-celled promycelium with two nuclei in each cell.

Fig. 32. Irregular distribution of nuecli in the sporidia. The central sporidium has received all the nuclei while the other sporidia received no nuclei.

Fig. 33. Four-nucleate condition in the promycelium.

Fig. 34. Bi-nucleate condition in the promycelium ; one daughter nucleus has undergone reduction division as indicated by the two groups of two chromosomes.

Fig. 35. Two sporidia which developed long hyphae after each had received a pair of nuclei.

Fig. 36. Another mode of conjugation between two sporidia.

Fig. 37. Irregular distribution of nuclei. One sporidium has received one nucleus while the other one has received three nuclei.

Fig. 38. Various stages of development of chlamydospores of *U. anemones* in the host of *Ranunculus repens*. a, early stages of spore balls, coiling and twisting of the hyphae especially towards the end are most pronounced ; b, a later stage ; c, a group of young fertile spores covered by sterile cells, contents of the sterile cells have already disappeared making them lighter in colour ; d, matured chlayydospores before the formation of outer thick wall ; e, matured chlamydospores with thick outer wall and attached sterile cells.

Fig. 39. T. S. of a leaf of *Ranunculus repens* infected with *U. anemones*, showing the hypertrophic condition of the cells, chlamydospores in the pustules and hyphae in the inter-cellular spaces.

A CHYTRIDIACEOUS PARASITE OF LIMNANTHEMUM INDICUM

By M. J. THIRUMALACHAR

(Accepted for publication May 12, 1949)

CHYTRIDIACEOUS parasites of flowering plants are of much interest on account of their rarity, mode of parasitism and in many cases for possessing peculiar adaptations for subaerial habitat. Of the several chytridiaceous parasites that are known to occur on phanerogams, some species of *Physoderma* (including the gall forming species originally placed under the genus *Urophlyctis*) have been investigated in detail. Studies by Jones and Drechsler (1920) and Sparrow (1946, 1947a, and 1947b.) have greatly contributed towards our knowledge of the genus. While making collections of the smut group *Doassansia* and *Burrillia* on aquatic plants near Bangalore, the writer had opportunity to collect a *Physoderma* species parasitic on the leaves of *Limnanthemum indicum* Thw. a member of the Gentianaceae. A brief account of the studies carried out by the writer is presented here.

SYMPTOMS

Limnanthemum indicum is a partially submerged plant with free floating leaves. It is attacked by a fungus which incites the formation of numerous warty galls on the lower surface of the leaves. As in many other partly submerged plants, the upper surface of the leaves is aerial and the lower surface in contact with water, so that the galls are always immersed in water. Under field conditions it is difficult to locate the infected leaves since the galls are on their underside and submerged in water. However, their presence is indicated by small yellowish specks on the upper surface.

The galls are tuberous (Fig. 1), warty and of various sizes, ranging from 2 to 8 mm. in diameter. They are usually yellowish-white in colour, but in several instances possess green colour due to the presence of chloroplasts in the outermost cells. When these galls were first collected in a pond near Bangalore, they were mistaken for bulbil-like structures of the host, probably functioning as organs of vegetative reproduction. Several of these galls developed robust adventitious roots (Fig. 2) which further added to the confusion in being mistaken for bulbils. When the galls are fully developed, the surrounding leaf tissue usually decays. This results in the separation of the galls from the leaves, leaving a shot-hole on the leaf surface.

MATERIALS AND METHODS

The anatomical structure of the galls as well as cytological studies were made in microtome sections. The material was fixed in Allen's modification of Bouin's fluid and stained with Newton's iodine-gentian-violet with orange G. as a counter-stain. For studying the stages of spore development and rhizomycelium, young galls were dissected out and mounted in lactophenol to which enough acid fuchsin was added to give a cherry-red colour. For germinating the resting spores, the mature galls were teased out and the separating spores were placed on coverglass as hanging drop preparations.

OBSREVATIONS

Although the early stages of the gall formation on the leaves has not been traced, evidence from more mature stages indicates a similar type of development found in *Urophlyctis* (= *Physoderma*) *alfalfae* described by Jones and Drechsler (1920).

The galls assume a pseudostem-like structure and represent a seat of extreme meristematic activity. The vascular bundles composed of numerous tracheids are drawn towards the centre of the gall from the leaf traces. The parenchymatous cells show rapid multiplication and produce hyperplastic cells. In sections through the root forming region of the gall, the groups of cambial cells actively dividing and initiating the lateral root formation were observed. In sections through the galls which are greenish, the outermost layers show sparsely distributed chloroplasts.

The sori within the gall are formed in locules or cavities, in which the resting spores are aggregated (Fig 3). The walls of the cells bordering the cavity do not show any thickening. The galls enlarge in size following the multiplication of parenchymatous cells, and a large number of young sori are produced in a centrifugal manner. Cytological studies indicate that the turbinate organs and the resting spores are multinucleate. The development of the rhizomycelium, characteristic of the endobiotic polycentric phase of the fungus, was observed in lactophenol mounts and could not be noticed in microtome sections.

The rhizomycelium traverses through the host tissue bearing numerous turbinate organs at frequent intervals. These are thin-walled, polygonal in outline and non-septate. Numerous secondary branches developing from these turbinate organs bear resting spores at their apices, each with a whorl of haustorial processes. Several of the resting spores showed direct development of turbinate organs arising on the side away from the flattened surface of the spore. Unlike as in the case of rhizomycelial branches, these were borne on stout stalks.

Some of the immature spores were teased out on slides and mounted on drops of water and inclosed in moist chambers at room temperature (24° C.). Observations at the end of 8 hours showed the formation of rhizomycelial branches arising from the sides of the spores and swelling at their apices into turbinate organs (Fig. 4). Descriptions of spore development given by Jones and Drechsler in *Urophlyctis alfalfae* indicate that the rhizomycelial branches are usually produced from the turbinate organs.

Mature resting spores are asymmetric, polygonal and flattened on one side (Fig. 6). Young spores show a whorl of acicular, bifid or often antler-like haustorial processes which are connected with the inner cytoplasm and project out at the angular regions (Fig. 5). Mature spores were pale cinnamon-brown, thick-walled and measure 16-27 μ in diameter. The haustorial processes break down at maturity but persist as stumps on the spore wall.

Germination of the resting spores has been observed in very few cases. The spores germinated after prolonged incubation in moist chamber for 5 to 6 days. The resting spore splits and germinates by the circumscissile dehiscence of a lid releasing the zoospores (Fig. 7). In many instances the exact mode of dehiscence could not be followed due to the paucity of germination stages. The development of the monocentric epehemeral sporangial stage was not observed.

Regarding the identity of the fungus under investigation, a comparative study indicates that it differs from other known species of *Physoderma* so far described. *P. menyanthis* described by de Bary (1864) occurs on a closely related host genus *Menyanthis trifoliata*, also a member of the Gentianaceae. The fungus incites the formation of small pustulate spots with sparsely distributed resting spores (Sparrow, 1946) in contrast to the gall formation in the species on *Limnanthemum indicum*. Comparisons of the structure and measurement of the resting spores indicate that the two are different.

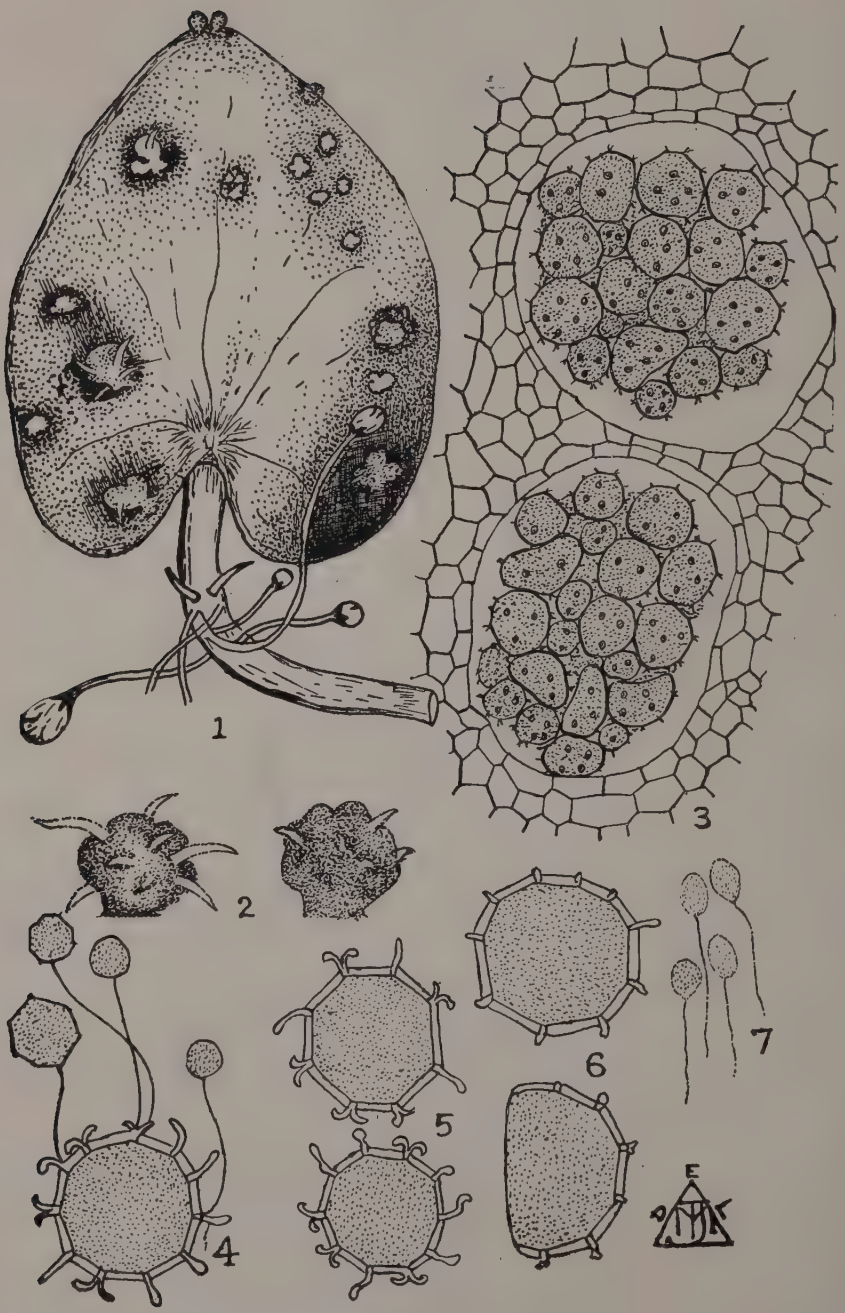


Fig. 1 to 7. See text for explanation.

Physoderma limnathemi sp. nov.

Inducing tuberous gall formation on leaves; galls bulbil-like, hypophyllous, yellowish-white to green. Mature resting spores developed in pockets, densely grouped, pale cinnamon-brown, angularly globoid to polygonal, 16-27 μ in diam.

Hab. in the leaves of *Limnanthemum indicum* Thw., Bannerghatta, Bangalore, 4-4-1949, leg. M. J. Thirumalachar.

Inducit tuberum formationem in foliis; tubera similia bulbulis, hypophylla, luteo-albida ad viridia. Quiescentes maturae sporae evoluta in cavernulis, dense aggregate, pallide cinnamomo-brunnea, angulariter globoidea, ad polygonalia, 16-27 μ diam.

Habitat in foliis *Limnanthemi indici* Thw.

In conclusion the writer wishes to acknowledge his indebtedness to Rev. Father Dr. H. Santapau, St. Xavier's College, Bombay, for kindly providing the latin diagnosis of the new species.

Mulleswaram,
Bangalore, India

REFERENCES

Bary, A.de. (1864). .. Beiträge zur Morphologie und Physiologie der Pilze. Erste Reihe. *Protomyces* und *Physoderma*. *Abh. senckenbergisch. Naturf. Ges.* **5**: 137-232, (original not seen)

Jones, F. R. and Drechsler Chas. (1920). .. .. Crownwart of alfalfa caused by *Urophylyctis alfaelfae* *J. Agric. Res.* **20**: 295-324

Sparrow, F. K. (1946). .. Observations on the chytridiaceous parasites of Phanerogams. I. *Physoderma menyanthis* de Bary. *Amer. J. Bot.* **33**: 112-118

(1947a). .. Observations on the chytridiaceous parasites of Phanerogams. II. A preliminary study of the occurrence of ephemeral sporangia in *Physoderma* disease of maize. *Amer. J. Bot.* **34**: 94-97

(1947b). .. Observations on the chytridiaceous parasites of Phanerogams. III. *Physoderma claytoniana* and an associated parasite. *Amer. J. Bot.* **34**: 325-329

Explanation of figs.

Fig. 1. Infected leaves of *Limnanthem indicum* x nat. size
Fig. 2. Enlarged view of the galls x 2 nat size
Fig. 3. Section through the sorus x 300
Fig. 4. Showing the formation of rhizomycelium from immature spore x 1000
Fig. 5. Immature spores showing haustorial processes x 1000
Fig. 6. Mature spores x 1000
Fig. 7. Zoospores x 1800

STOMATAL INVASION OF CABBAGE BY XANTHOMONAS CAMPESTRIS (PAMMEL) DOWSON

By V. P. BHIDE*

(Accepted for publication May 30, 1949)

Xanthomonas campestris (Pammel) Dowson, the cause of 'black rot' of cabbage, normally invades the host through hydathodes situated on the leaf margins at the terminations of veins. Drechsler[1] obtained stomatal invasion of cotyledons of cabbage seedlings but true leaves failed to take infection in a like manner. The reasons why stomatal invasion cannot occur in the 'black rot' of cabbage have not been investigated but one of the reasons could be the nature of the leaf surface; cabbage leaves are covered with a thick coat of wax and this does not allow formation of a film of water on the leaf surface, so essential for bacterial invasion through stomata. Anderson and Henry[2], working with *Piricularia oryzae*, found that use of sodium oleate as a surface tension depressant and gelatin as an adhesive incorporated in a water suspension of spores of this fungus gave higher amounts of leaf infection on rice seedlings than a spore suspension made in plain water alone. The most effective combination of the chemicals in their experiments was 0.05 per cent sodium oleate and 0.25 per cent gelatin. It was thought worthwhile to try these chemicals on cabbage, and the following is an account of the trials carried out by the author in the Botany and Plant Pathology Department, Iowa State College, Ames, Iowa, U. S. A.

Before conducting the inoculation trials it was necessary to determine the limiting concentrations of sodium oleate and gelatin which would not be toxic to the 'black rot' organism and at the same time be high enough to be effective on cabbage leaves. One per cent solutions of the two chemicals were therefore prepared and dilutions ranging from 0.01 to 0.05 per cent sodium oleate in 0.25 per cent gelatin water were made. Test tubes were filled with the various solutions, sterilized and inoculated lightly with a culture of *Xanthomonas campestris* of proved pathogenicity. Duplicate tubes were inoculated in each case. Distilled, sterile water served as a check. The viability of the organism in the various concentrations of sodium oleate was determined by making transfers to agar slants at the end of 12, 36, and 72 hours. The results showed that the organism could withstand a concentration of 0.05 per cent sodium oleate in 0.25 per cent gelatin water for 72 hours.

Young cabbage seedlings (*var.* Early Jersey Wakefield), with four leaves each were sprayed with suspensions of *Xanthomonas campestris* made up in sterile water containing 0.25 per cent gelatin and 0.01, 0.03, and 0.05 per cent sodium oleate respectively. The plants were placed in a moist chamber for 72 hours before and after spraying them with the bacterial suspensions. Eight plants of cabbage were used in each case. It was observed that the suspensions containing 0.03 and 0.05 per cent sodium oleate spread evenly on the leaf surface whereas suspensions made in plain water alone accumulated in drops on the leaves and ran off.

---

* Present address: College of Agriculture, Dharwar

1. Drechsler, Charles (1919). Cotyledon infection of cabbage seedlings by *Pseudomonas campestris*. *Phytopathology* 9 : 275-282

2. Anderson, Axel L. and Henry, B. W. (1946). The use of wetting and adhesive agents to increase the effectiveness of conidial suspensions for plant inoculation. *Phytopathology* 36 : 1056-1057

Five days after the plants were sprayed with bacterial suspensions, two plants where 0.03 per cent sodium oleate was used showed symptoms of stomatal invasion by the bacteria. This was evidenced by the 'leaf-spot' type of lesions occurring on leaves away from the margins. In hydathode invasion lesions start along the margins of the leaves where the bacteria gain entrance. All the plants showed the marginal lesions in ten days. The stomatal lesions enlarged somewhat in size, but in a short time the lesions originating from the margins of the leaves enlarged rapidly and coalesced with the stomatal lesions. Isolations from both the types of lesions yielded the 'black rot' organism quite readily.

The experiment was repeated using only one strength of sodium oleate, 0.03 per cent, since this concentration gave the best results. Plants of three different ages were used : two weeks, one month and two months. The technique of spraying the plants was the same as before. Seven days after the plants were sprayed, numerous small lesions appeared on a large number of plants of all the ages. At the same time, marginal infection was also evident in all cases. The stomatal lesions were less on the leaves of younger plants than on those of older plants. On leaves of one and two month old plants, the spots were small, about 1-2 mm. in diameter and contained dead brown areas in their centres. On younger plants, the spots appeared as small, yellow areas but these did not enlarge to any appreciable extent. Hydathode infection was severe in plants of all ages, and the lesions originating from this type of infection soon covered the majority of the leaf areas and progressed downwards in the petioles and stem. At the same time, the spots resulting from invasion through the stomata remained very small and did not show any enlargement, indicating that the bacteria had failed to establish themselves in the sub-stomatal chambers and make any further progress inside the leaves.

These results indicate that stomatal infection is possible in the 'black rot' of cabbage but that the pathogen cannot establish itself in the plant in this manner as it cannot reach the vascular elements in the leaves. This may be due to the inability of the bacteria to grow in the intercellular spaces below the stomata due to lack of nutrients or other causes. Moreover, the bacteria cannot directly enter the vascular system of the plant in this manner but this is possible in the case of invasion through the hydathodes.

The phytopathogenic members of the genus *Xanthomonas* usually cause 'leaf-spots' and 'blights' on their hosts ; *Xanthomonas campestris* and *Xanthomonas lespedezae* are the only exceptions as these two cause vascular necrosis. All the members of this genus are very much alike in their cultural and physiological characters and can be differentiated from each other only on the basis of their pathogenicity to their particular hosts. Why is it then that the above two species only should be restricted to the vasuclar system of their hosts ? One of the factors may be the inability of the wilt producers to attack cell walls of the leaf tissues. These organisms have very simple nutritional requirements and it seems doubtful that their inability to grow in the intercellular spaces is due to lack of proper nutrition. The only feasible possibility seems to be the inability of the wilt producers to elaborate one or more enzymes or chemicals that would break down the cell walls, whereas the 'leaf-spot' and 'blight' producers have this ability.

Botany and Plant Pathology Department,
Iowa State College,
Ames, Iowa. U. S. A.

STUDIES IN AQUATIC PHYCOMYCETES

By R. C. LACY

(Accepted for publication July 27, 1949)

This list records four aquatic Phycomycetes isolated and studied from collections made by the author in January and February, 1949. These are new records for India and one is proposed as a new species.

1. LAGENIDIUM ENTOPHYTUM (Pringsheim) Zopf

Thallus occupies the central position in the host cells of *Spirogyra* sp. (cells roughly measure 90 x 126 μ in size). Infection is restricted to individual cells of the host and does not travel from cell to cell. The parasite was found to attack the vegetative cells as well as the conjugating filaments and their zygospores.

It appears that the infection centres round the nuclear region of the cell of the host. The thallus is irregularly branched, sending out short, primary, secondary and even tertiary branches with numerous swellings and protuberances. The thalli are continuous without cross-walls, except at the base of the oogonia. The hyphae are relatively thick, 4 to 8μ. The protoplasm contains numerous refractive globules, giving a characteristic whitish gleam to the cell. Numerous protuberances or sporangia-like swellings are found in the thallus, but no definite sporangia or exit tubes, or spores were observed in the collected material.

Oogonia were found on older thalli in fairly large numbers. They are cut off from the thallus by a septum and are spherical, smooth-walled bodies, about 12μ in diameter. They appear to develop parthenogenetically into thick-walled and rough-coated oospores, 12 to 18μ in diameter. The granular, hyaline contents of the oogonia develop one or two large refractive globules at the time of oospore formation and then the entire oogonium gets encysted, forming thick, warty coat of 2-3 layers, brown in colour. No distinct antheridia could be found.

Germination of the oospore was not seen, though some of the empty oospore-cases were found left in the thallus.

On *Spirogyra* sp. Collected at Jalla, Patna on 13-2-1949. Figure 1, A.

2. ENTOPHLYCTIS BULLIGERA (Zopf) Fischer

As shown in Fig. 1, B, *Entopheyctis* was found parasitizing the old and dying filaments of *Spirogyra* sp., which was further infected with *Lagenidium entophytum*. In certain cells both the parasites were found together.

Valkanov (1931) gives the diameter of the sporangium as 17-18μ. Schroeter (1897) records the size as 25 μ, but such large sporangia were not found in this collection. Here, the size of the sporangia ranges from 12-20 x 8-16 μ, with the epibiotic knob about 4 μ in diameter. These measurements correspond with those of Domjan (1936). The shape of the sporangium is typically spherical, with its epibiotic knob, which can, at places, be seen to project outside the cell wall as shown in Fig. 1, B, k. This knob has been described by Zopf (1885) as the body of the infecting zoospore, which persists and acts as a sporangial neck and papilla for the escape of the newly formed zoospores.

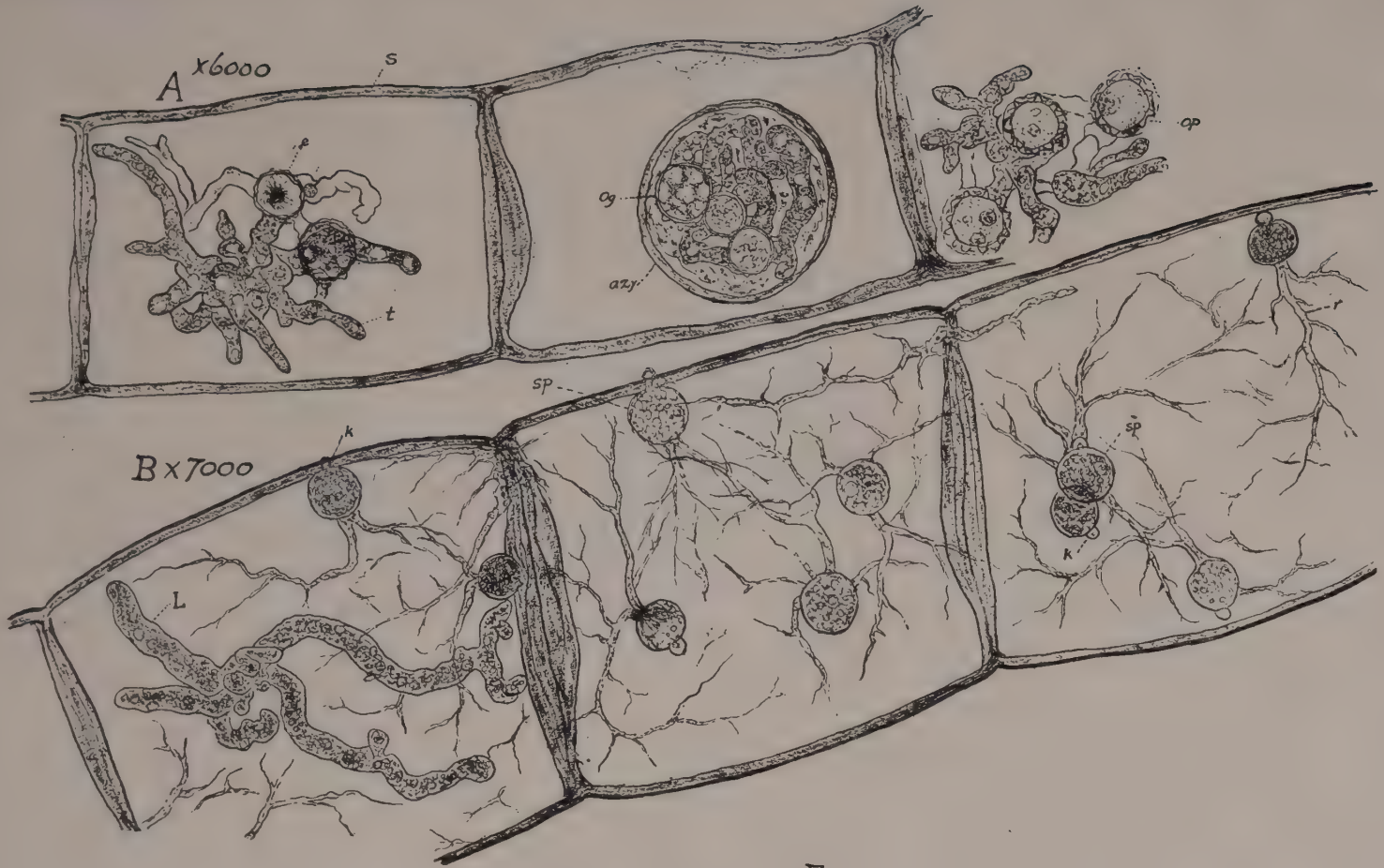


Figure 1

See text for explanation.

The wall of the sporangium and the epibiotic knob are slightly thickened and well-differentiated from the wall of the rhizoidal system. Sporangia were seen to show developing zoospores as round masses of protoplasm in them. Their number may roughly range from 30 to 40 in each sporangium. The sporangium frequently shows a slight depression at the point of attachment of the epibiotic knob.

The rhizoidal system generally arises from the lower side of the sporangium at one or several places. It may be 4μ at the point of origin, but generally tapers to fine hairy structures, extensively branched in all directions like a root system. It is either confined to a single cell of the host or travels to the neighbouring cells also. The infected cells of the host do not show much content, indicating the damage caused by the fungus. It infects the vegetative as well as conjugating filaments of *Spirogyra* sp. Resting spores were not observed in this collection.

On *Spirogyra* sp. Collected at Jalla, Patna on 13-2-1949. Figure 1, B.

3. CHYTRIDIUM OLLA Braun

Sporangia of *Chytridium olla* were found attached to the oogonia and oospores of *Oedogonium* sp. either singly or in clusters of 5 to 8 (Fig. 2, C, sp). They are generally sessile, ovoid, 48-24 x 36-12 μ in size, with an umbonate operculum, about 12μ, projecting at the apex and with transverse striations. The sporangia are very variable in shape.

Zoospores, at all stages of their development, were seen inside the sporangium. At maturity, the operculum of the sporangium is thrown off and the spores escape, leaving the empty sporangia (Fig. 2, C, esp). The curious production of flamelike refractive out-growths of the sporangial wall as noted by Sparrow (1943), was not seen in this collection.

The hyphal system is poorly developed. It is generally a short, unbranched stalk, embedded in the tissues of the oogonium of the host. It is about 8μ in diameter and the sporangium develops at its end. The rhizoidal system was not seen to show branching or septation as described by some workers.

On *Oedogonium* sp. Collected at Bahadurpur, Patna, from a stream on 20-2-1949. Figure 2, C & C'.

4. APHANOMYCES APOPHYSII Lacy sp. nov.

Mycelium intra-cellular, irregularly branched, aseptate, coarse, usually 8μ thick, with occasional swellings and regular apophysis from 20 to 30μ in diameter Hyphae with vacuoles of various sizes and refractive globules.

Sporangia long, thread-like, more or less straight, characterised by the formation of apophysis at their base ; developed singly, or several emerging from same host cell, ranging in length from 300 to 500μ and in diameter from 8 to 12 μ; swarmspores arranged in sporangia in single rows, getting encysted when discharged, later escaping leaving empty cysts.

Homothallic ; oogonium spherical, terminal or intercalary, borne on short stalks with a single egg ; antheridial filaments attaching singly or in groups to oogonia ; oogonia measuring 20 to 24μ ; oogonial wall 3μ thick, without pits, hyaline.

Oospore brown, 35 to 40μ in diameter, thick-walled, star-shaped, covered with several spine-like perpendicular projections; projections about 5μ long, presenting a beautiful starry appearance.

On *Spirogyra* sp. Collected from a big pond, near village Bahadurpur, Patna on 20-1-1949. Figure 2, D and Fig. 3 (photo).

Mycelium intra-cellulare, ramis irregulribus, aseptatis, crassis, fere semper 8μ dia., modo bulbo interdum, apophysi regulari, 20-30μ dia. Hyphae vacuolates mensuris diversis globulosis refractivis.

Sporangium longum, filiformotum, fere semper rectum, modo peculiare apophysi apud fundamentum semper praedita, tum singulum tum multa ex cella eadem in qua fixa emergentes, aut 300-500μ long; et 8-12μ dia., conglomeratae sporæ uneseriate modo; emergentes encystate, cystis evacuates eruptae.

Homothallicum; oogonium sphericum, terminale aut intercalare, unico ovo pedice breviato, filamentis antheridialibus aut singilatum aut multiplicitae ad oogonium fixum; oogonium 20-24μ dia., pariete 3μ dia., hyaline, non-lacunosum.

Oosporum brunneoum, 35-40μ dia., pariete denso, stellatum, contectum spinulatis exlatere projectis modo perpendiculare, circa 5μ long, visu stellato et pulchro.

The fungus was found parasitizing the conjugating filaments of *Spirogyra* sp. All the conjugating filaments do not show the infection. It appears that the infection is very likely dependent on the low vitality of the filaments.

The infection starts from the male filament and the hyphae travel longitudinally from cell to cell in the male filament, which is either in the process of gamete formation or has already transferred its contents into the female filament forming zygospores (Fig. 2, D). Later, some of the infection hyphae also pass through the conjugation tube to the newly-formed zygospores, which get heavily infected. In the host, the infected zygospores show disintegration of their outer regions. Due to the activity of the fungus, light and shade areas begin to appear and the hyphæ emerge in all directions.

In its course from cell to cell or outside the cell, the hyphae have to penetrate the cross-walls. They first develop a bulging to exert a pressure against the obstruction and then send out a thin penetration tube, which emerges into regular hypha. This bulged portion of the hyphæ near the cross-wall before the formation of the constriction appears to be a very characteristic feature of the fungus and has been termed as "apophysis" in this description. The direction of the invasion of the fungus can also be found out by the position of apophysis against the host wall.

As the infection proceeds, the older cells of the host and parasite become empty and appear to be dead. But, before they actually lose their content, they send a few hyphæ through the conjugation tubes of *Spirogyra* to the zygospores. These hyphæ in the female filament look fresh and vigorous in their activities and contain granular and vacuolated substance.

The fungus is characterised by the presence of irregularly branched, aseptate, coarse-looking mycelium, usually 8μ thick, but with occasional swellings and regular apophysis from 20 to 30μ in diameter. The granular contents of the hyphæ also show variously sized vacuoles and refractive globules in them. The hyphæ are intracellular, except when they emerge to form sporangia.

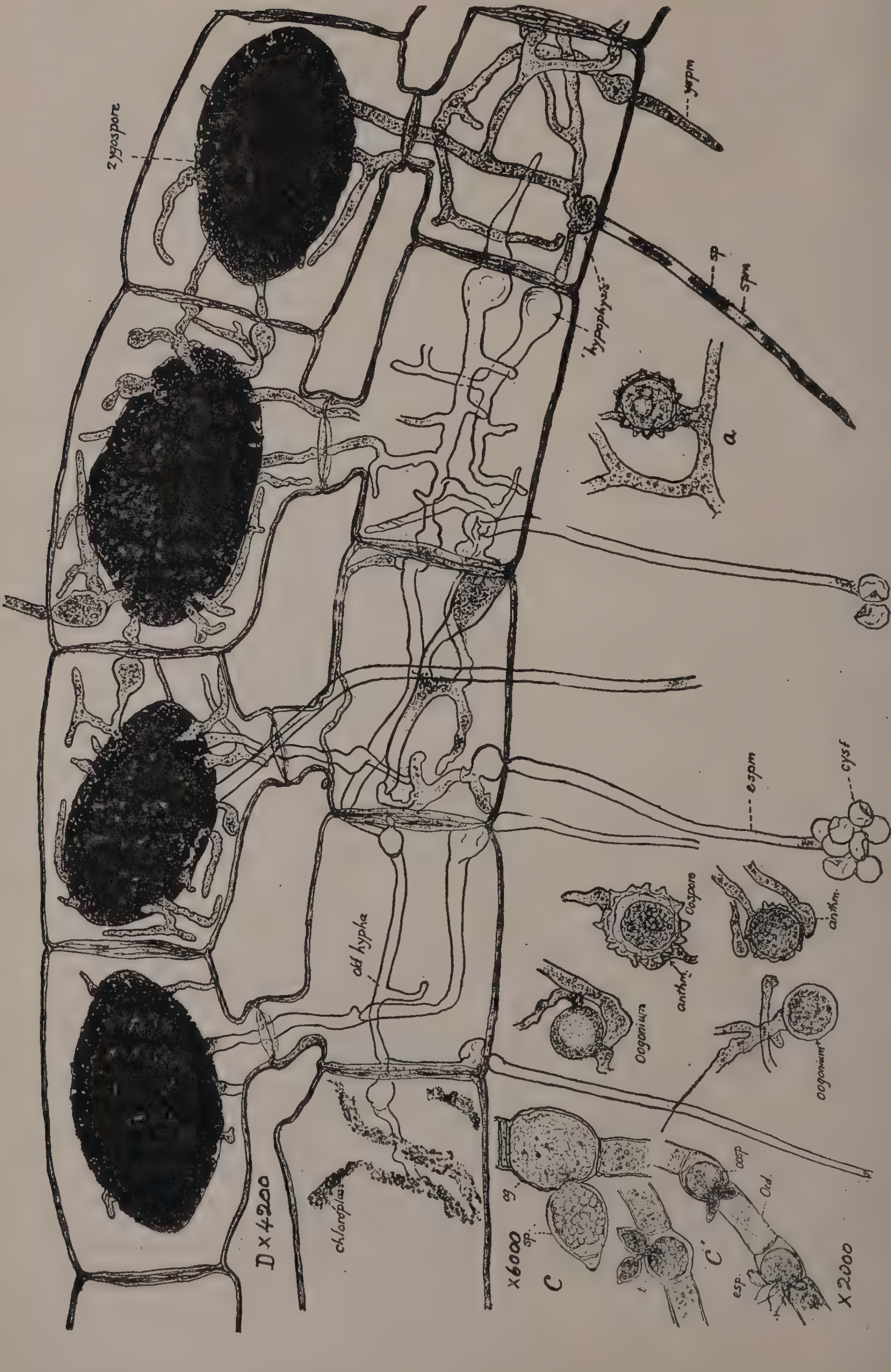

zygospore
ypm
sp
spm
hypophyses
a
espm
cyst
Oospore
anthm.
oogonium
old hypha
chloroplast
D x 4200
x 6000
C
og
sp.
C'
oosp
Ood.
esp.
X 2000

Figure 2.

The sporangia are long, thread-like, more or less straight structures. They are also characterised by the formation of apophysis at their base. They are developed singly, but several may emerge from the same cell of the host. They are called swarmsporangia as the plasma portion of the swarmspores are separated in them before the swarmspores are actually let out (Fig. 2, D, sp). The sporangia range from 300 to 500μ in length and about 8-12μ in diameter. The swarmspores are arranged in the sporangia in a single row.

At maturity, the swarmspores gather at the tip of the sporangium and get encysted. Later, the zoospores escape, leaving the empty cyst cases (Fig. 2, D, cyst). A large number of cysts show apertures through which the zoospores have escaped. In the beginning, the sporangium shows a pointed tip, but when the zoospores have been discharged, it shows a gaping tip, which may show a few left-over plasma of the swarmspores.

Sexual reproduction takes place in the host cells, generally when the contents of the host have been disintegrated and used up. It is homothallic. The oogonium is spherical, terminal or intercalary structure ; borne on a short stalk and containing a single egg. The antheridial filaments attach themselves singly or in groups to the oogonium. They arise from the same filament or from different ones. Oogonia measure from 20-24μ ; they have no pits on their walls ; the wall is about 3μ thick and hyaline. In some cases, the egg is moved and attached to one side of the oogonium and consequently so in the oospore also. They are all borne on the inside of the host (Fig. 2, D).

Actual fertilization has not been observed, but in some of the young oospores (Fig. 2, D, a), two nuclei-like structures were seen associated together, suggesting fertilization. Oospore is brown in colour, thick-walled, star-shaped, covered with numerous spine-like perpendicular projections, about 5μ long and presenting a beautiful starry appearance in the empty cells of the host. They are from 30-40μ in diameter.

Oospores form at the very last stages of the host and by that time the hyphæ of the parasite also lose their contents and begin to disappear. Evidently, this is the resting stage of the fungus, and germination can be expected after a resting period. But, in a few oospores, a tiny, vigorous germ-tube was seen to come out. Regular germination studies were not made.

This species of *Aphanomyces* resembles *A. phycophilus* de Bary in most details ; but has its own characteristic features :

1. Tendency to attack first the male filament of *Spirogyra* sp. and then the female filament.

2. Presence of characteristic bulgings at the cross-walls of host, here termed as "apophysis".

3. Oogonia borne inside the host cell and none on the outside.

4. Size of oogonium is considerably smaller.

The author wishes to record his thanks to Dr. B. B. Mundkur, New Delhi for his help and suggestions and to Rev. M. D. Moran, S.J., St. Xaviers, Patna for his help in the preparation of the Latin diagnosis of the new species.

SUMMARY

In the foreoging paper are described four phycomycetous fungi, namely, *Lagenidium entophytum*, *Entophlyctis bulligera*, *Chytridium olla* and *Aphanomyces apophysii* collected in the vicinity of Patna in the months of January and February, 1949. *Chytridium olla* was found parasitic on *Oedogonium* sp., while all the others were found parasitic on *Spirogyra* sp. The first three are new records for India and the last is proposed as a new species.

Department of Botany,
Science College, Patna

REFERENCES

Coker, W. C., 1923. .. The Saprolegniaceae, with notes on other water moulds. Chapel Hill, N. C.

Domjan, A. 1936. .. "Vizigombas" etc. *Folia Cryptogam.*, **2** (1) : 8-59, pl. 1. (Original not seen)

Fitzpatrick, H. M., 1930. The Lower Fungi. Phycomycetes. New York

Karling, J. S., 1931. .. Studies in the Chytridiales V. A further study of species of the genus *Entophlyctis*. *Amer. J. Bot.* **18** : 443-464

1942. .. Simple holocarpic biflagellate Phycomycetes. New York City

Sparrow, F. K., 1943 .. The Aquatic Phycomycetes. Univ. of Michigan Press

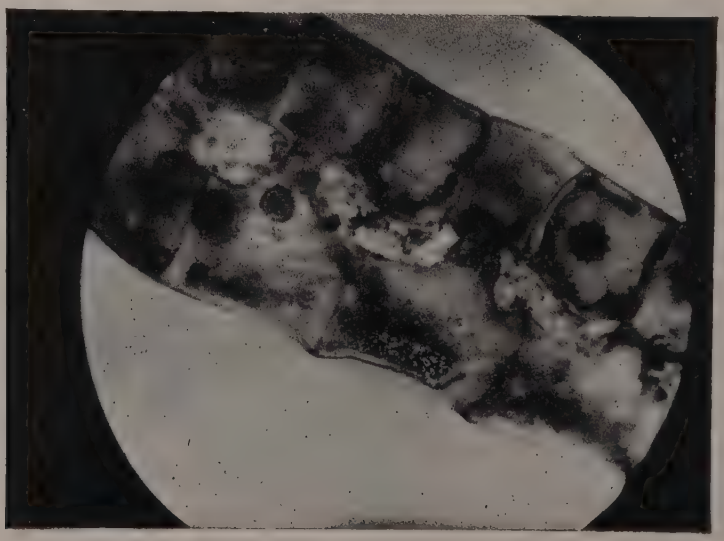


Fig. 3. See text for explanation

Schroeter, J., 1897. .. Chytridineae. Engler & Prantl, Die natürlichen Pflanzenfamilien, Leipzig

Valkanov, A. 1931. .. Protistenstudien. 7. Beitrag zur kenntnis der Susswasserphycomyceten Bulgariens. *Arch. Protist.* **73**: 361-366. (Original not seen)

Zopf, W., 1885. .. .. Zur Kenntnis der Phycomyceten I. *Nova Acta Kais. Leop. Carol Deutsch Akad. Nat.* **47**: 142-237 (Original not seen)

Explanation of Figures

Figure 1. A. *Lagenidium entophytum* infecting vegetative cells and azygospore of *Spirogyra* filament. S, *Spirogyra* filament; e, empty oospore; t, thallus of *Lagenidium*; azy, azygospore; og, oogonium; op, oospore. x 6000.

B. *Entophlyctis bulligera* infecting *Spirogyra* filament, r, rhizoidal system; sp, sporangium; k, epibiotic knob. x 7000.

Figure 2. C. *Chytridium olla* infecting oogonium of *Oedogonium*. og, oogonium; sp, sporangium of *C. olla* with numerous zoospores. x 6000.

C'. Same, but sporangia in pairs or clusters, attached to oospores; t, rhizoidal tube; oosp, oospore of *Oedogonium*; esp, empty sporangia after discharging their zoospores. x 2000.

D. Conjugating filaments of *Spirogyra* infected with *Aphanomyces apophysii* sp. nov; spm, sporangium; yspm, young sporangium; espm, empty sporangium; a, oospore, probably showing the association of male and female nuclei. x 4200.

Figure 3: (photo). Conjugating filaments of *Spirogyra* infected with *Aphanomyces apophysii*, showing the formation of star-shaped oospores in the conjugating filaments of host.

FUNGI OF BOMBAY, SUPPLEMENT I

By M. K. PATEL, M. N. KAMAT AND V. P. BHIDE

(Accepted for publication July 30, 1949)

SINCE the publication of the "Fungi of Bombay" by Uppal, Patel and Kamat (29) 14 years ago, extensive surveys of diseases affecting the agricultural and horticultural crops have been carried out, as a result of which, several new records of fungi have been made for the state. Fungi have also been collected in the state by others, principally Sedgewick, Santapau and Mundkur. As a result of all these activities, 164 new records have been made, affecting 200 host plants, which are reported in this paper.

Special mention must be made of 11 bacterial diseases affecting 36 host plants that have been reported here. It may be mentioned that comprehensive investigations on these diseases are at present carried out only in this laboratory in India. Four other bacterial diseases are also under investigation but they are not included in this paper, as the investigations are not yet complete and may take some time.

The fungi have been arranged alphabetically in each of the sub-groups of Phycomycetes, Ascomycetes, Basidiomycetes and Fungi Imperfecti, besides Schizomycetes and Viruses. Synonyms of the more important fungi have been given and a host index is included to facilitate reference.

Most of the specimens have been deposited in the Herbarium of the Plant Pathologist, Bombay State, Poona.

The writers are greatly indebted to Dr. B. N. Uppal, Director of Agriculture, Bombay State for his unfailing interest and for the encouragement he gave in the preparation of this list and to Drs. B. B. Mundkur and M. J. Thirumalachar for going through the list and suggesting corrections and additions. Help rendered by their colleagues in the laboratory in compiling the list and in typing the manuscript for the press is also sincerely acknowledged.

SCHIZOMYCETES

Bacterium carotovora Jones (23)

Causing rot in *Beta vulgaris*, *Brassica oleracea-botrytis*, *Capsicum annuum*, *Citrus sinensis*, *Cucumis sativus*, *Daucus carota*, *Hibiscus esculentus*, *Ipomoea batata*, *Lycopersicum esculentum*, *Mangifera indica*, *Musa sapientum*, *Phaseolus vulgaris*, *Pisum sativum*, *Raphanus sativus*, *Solanum tuberosum* and *Vigna catjang*, General

Pseudomonas mangiferae-indicae Patel, Moniz and Kulkarni (22)

On leaves and fruits of *Mangifera indica*, General

Xanthomonas campestris (Pam.) Dowson (24)

Causing soft rot of *Brassica campestris* var. *glauca*, *Brassica juncea*, *Brassica oleracea*, *Brassica oleracea* var. *botrytis*, *Brassica oleracea* var. *caulorapa*, *Brassica nigra*, *Brassica campestris* var. *rapa* and *Raphanaus sativus*, General

Xanthomonas citri (Hasse) Dowson

On leaves, stems, petioles and fruits of *Citrus sinensis*, General

Xanthomonas desmodii Uppal and Patel (19)

On leaves of *Desmodium diffusum*, Poona

Xanthomonas desmodii-gangetici Uppal, Patel and Moniz (19)
On leaves of *Desmodium gangeticum*, Bassein
Xanthomonas malvacearum (Smith) Dowson (20)
On leaves, stems and bolls of *Gossypium hirsutum*, General
Xanthomonas phaseoli var. *indicus* Uppal, Patel and Nikam (40)
On leaves of *Dolichos lablab*, *Phaseolus coccineus*, *Phaseolus lunatus* and *Phaseolus vulgaris*, General
Xanthomonas phaseoli var. *sojense* (Elliot) Dowson (32)
On leaves of *Glycine soja*. General and *Dolichos biflorus* (21), Nipani
Xanthomonas Uppalii Patel, (18)
On leaves of *Ipomoea muricata*, General
Xanthomonas vignicola Burkholder (10)
On leaves, stems and pods of *Phaseolus vulgaris*, *Vigna catjang*, *Vigna sesquipedalis* and *Vigna sinensis*, Poona

PHYCOMYCETES

CHYTRIDIALES

Physoderma maydis Shaw
On leaves of *Zea mays*, Dohad

OOMYCETES

Bremia graminicola Naoumoff var. *indica* Patel (17)
On leaves of *Arthraxon lancifolius*, Mahableshwar
Cystopus-evolvulae Damle
On leaves, stems and fruits of *Evolvulus alsinoides*, Poona
Peronospora amaranthi Gaümann
On leaves of *Amaranthus bliti*, Poona
Peronospora effusa (Grev.) Rabenh.
On leaves of *Chenopodium album-viride*, Chakan
Peronospora parasitica (Persoon) De Bary
On leaves and pods of *Raphanus sativus* var. *caudatus*, Poona
Phytophthora parasitica Dastur
Pathogenic on fruits, tubers and plants of *Lycopersicum esculentum* and *Solanum tuberosum*, plants of *Clarkia elegans*, *Gossypium hirsutum*, *Opuntia* sp., *Ricinus communis*, *Sesamum indicum* and fruits of *Malus sylvestris*, *Solanum melongena* and *Psidium guajava*, Poona
Plasmopara wildemaniana macrospora Sawada (26)
On leaves of *Justicia simplex*, Mahableshwar
Pythium myriotylum Drechsler
On *Zingiber officinale*, Surat
Sclerospora graminicola (Sacc.) Schroeter
On leaves of *Pennisetum purpureum*, Dharwar and Kopargaon
Sclerospora sorghi (Kulkarni) Weston and Uppal
On leaves of *Zea mays* (oosporic stage on sweet maize) (27) and *Euchlaena mexicana*, Poona

ZYGOMYCETES

Rhizopus artocarpi Raciborskii
On fruits of *Artocarpus integrifolia*, Palasdhari

ASCOMYCETES

PLECTOMYCETES

Asterina celtidicola P. Henn. var *capparidis* (Sydow and Butler) Theiss
On leaves of *Capparis horrida* and *Capparis grandis*, Dharwar
Capnodium betle Sydow and Butler
On leaves and stems of *Piper betle* and *Piper trichostachyon*, General
Capnodium citri Berk. and Desm.
On leaves of *Citrus* sp., General
Diplocarpon (*Actinonema*) *rosae* Wolf
On leaves of *Rosa multiflora*, Mahableshwar
Erysiphe acaciae Blumer
On leaves of *Zyziphus jujuba*, Poona
Erysiphe cichoracearum DC.
On leaves of *Helianthus annuus*, *Papaver somniferum* and *Verbena* sp., Poona
Erysiphe polygoni DC.
On leaves of *Brassica rapa*, *Phaseolus mungo* var. *radiatus*, *Sesbania aegyptica* and *Vigna catjang*, Poona
Leveillula taurica (Lév.) Arn. (11)
On leaves of *Gossypium arboreum* var. *neglectum*, Kaira, *Abutilon indicum*, *Bridelia retusa*, *Cajanus cajan*, *Crotalaria juncea*, *Crotalaria usuramoensis*, *Gynandropsis pentaphylla*, *Impatiens balsamina*, *Lycopersicum esculentum*, *Martynia diandra*, *Medicago sativa*, *Nasturtium* sp., *Sesamum indicum*, *Solanum tuberosum* and *Tagetes* sp., Poona
Leveillula taurica (Lév.) Arn. var. *macrospora* Uppal, Kamat and Patel (30)
On leaves of *Dolichos lablab*, Poona
Meliola asterinoides Winter var. *major* Gill.
On leaves of *Canthium umbellata*, Mahableshwar
Meliola butleri Sydow
On leaves of *Citrus aurantium*, Poona
Parodiella smithiae Uppal, Patel and Bhide (41)
On leaves of *Smithia bigemina*, Mahbleshwar
Phyllactinia corylea (Persoon) Karst.
On leaves of *Morus alba*, Poona
Sphaerotheca humuli (DC.) Burrill
On leaves of *Cosmos* sp., Kirkee

PYRENOMYCETES

Mycosphærella arachidicola Jenkins
On leaves of *Arachis hypogæa*, General
Mycosphærella berkeleyii Jenkins
On leaves of *Arachis hypogæa*, General
Mycosphærella tinosporæ Ajrekar and Ojha
On leaves of *Tinospora cordifolia*, Ahmedabad
Phyllachora actinodaphnes Uppal, Patel and Bhide (41)
On leaves of *Actinodaphne hookeri*, Mahableshwar
Phyllachora repens (Corda) Saccardo
On leaves of *Ficus religiosa*, Ratnagiri
Stephanotheca Oleae Hansford and Thirumalachalar
On *Olea dioica*, Khandala

BASIDIOMYCETES

HEMIBASIDII

Liroa emodensis (Berkley) Ciferri
Syn. *Ustilago emodensis* Berk. (13)
In inflorescence of *Polygonum chinense*, Mahableshwar
Melanopsichium eleusinis (Kulkarni) Mundkur and Thirumalachar
Syn. *Ustilago eleusinis* Kulkarni (14)
In inflorescence of *Eleusine coracana*, Kolhapur
Sphacelotheca andropogonis-annulati (Brefeld) Zundel
In inflorescence of *Andropogon annulatus*, Poona
Sphacelotheca annulati (Ellis and Everhart) Mundkur
In inflorescence of *Dicanthium annulatum*, Poona
Sphacelotheca bursa (Berkley) Mundkur and Thirumalachar
Syn. *Ustilago bursa* Berkley (14)
In Inflorescence of *Anthistiria* sp., Bassein ; Surat
Tilletia ajrekari Mundkur (13)
In inflorescence of *Pennisetum typhoides*, Ahmedabad
Tolyposporium ehrenbergii (Kuehn) Pat. var. *grandiglobum* Uppal and Patel (34)
In inflorescence of *Andropogon purpurea* var. *sericeus*, Khandesh
Ustilago kolleri Wille
In inflorescence of *Avena sativa*, Mahableshwar
Ustilago polytocæ Mundkur (13)
In inflorescence of *Polytoca barbata*, Goshenhati

PROTOBASIDII

Aecidium crini Kalch. (14)
Syn. *Aecidium amaryllidis* Syd. and Butler
On leaves of *Crinum asiaticum*, Poona
Aecidium pavettae Berk.
Syn. *Aecidium flavidum* Berk
On leaves of *Pavetta indica*, Mahableshwar
Aecidium rhytismoides Berk. (13)
On leaves of *Diospyros melanoxylon*, Sirsi
Cerotelium fici (Cast.) Arthur
On leaves of *Morus alba*, Mahableshwar
Cystopsora oleæ Butler (13)
On leaves of *Oleas dioica*, Matheran ; Lonavala
Dasturella bambusina Mundkur and Kheshwala (13)
On leaves of *Bambusa* sp., General
Massecella capparidis (Hobson) Diet.
On leaves of *Flacourtia* sp., Belgaum
Olivea tectonæ (Raciborski) Thirumalachar
On leaves of *Tectona grandis*, General
Phakopsora zizyphi-vulgaris (P. Henn.) Diet.
On leaves of *Zizyphus jujuba*, General
Phragmidiella heterophragmii Mundkur and Thirumalachar (15)
On leaves of *Heterophragma roxburghii*, Khandala
Puccinia chrysanthemi Roze.
On leaves of *Chrysanthemum* sp., General
Puccinia heterospora B. and C.
On leaves of *Abutilon indicum*, Poona

Puccinia malanocephala Sydow
On leaves of *Bambusa* sp., Poona
Puccinia operta Mundkur and Thirumalachar
Syn. *Uredo operta* Sydow and Butler (15)
On leaves of *Coix lachryma-jobi*, Gir Hills
Puccinia ruelliæ (B. and Br.) Lagerh.
On leaves of *Ruellia prostrata*, Poona
Puccinia solmsii P. Henn.
On leaves of *Polygonum chinense* var. *ovalifolium*, Mahableshwar
Puccinia thwaitesii Berk.
On leaves of *Justicia gendarussa*, Poona ; Bassein
Tranzschelia punctata (Persoon) Arthur
On leaves of *Amygdalus persica*, Nasik
Trochodium riviæ Gharse
On *Rivea* Sp., Poona
Uromyces commelinæ Cooke (16)
On leaves of *Commelina forskalæi*, Ahmednagar
Uromyces decoratus Sydow
On leaves of *Crotalaria rustica*, Mahableshwar
Uromyces dolicholi Arthur
On leaves of *Rhynchosia minima*, Kirkee
Uromyces mucunae Rabenhorst
On leaves of *Stizolobium deeringianum*, Poona
Uromyces rumicis (Schum.) Wint.
On leaves of *Rumex vesicarius*, Poona
Uredinella spinulosa Couch and Petch (27)
On scale insects on *Gymnosporia rothiana*, Khandala

FUNGI IMPERFECTI

SPHÆROPSIDALES

Cryptostictus caudata (Preus.) Saccardo
On leaves of *Rosa* sp., Karjat
Diplodia epicocos Cooke
On fronds and fruits of *Cocos nucifera*, General
Diplodia natalensis Evans
On fruits of *Anona squamosa*, *Citrus aurantifolia*, *Citrus grandis*, *Citrus nobilis* var. *deliciosa*, *Citrus sinensis*, *Malus sylvestris*, *Mangifera indica*, *Prunus communis* and *Punica granatum*, General
Diplodia viticola Desm.
On leaves of *Vitis vinifera*, Poona ; Nasik
Diplodia sp.
On leaves of *Agave wightii*, Poona
Dothiorella sp.
On leaves of *Mangifera indica*, Kanara
Macrophoma sp.
On twigs and fruits of *Mangifera indica*, General
Macrophomina phaseoli (Maubl.) Ashby
On tubers of *Ipomœa batata* (12) at Dharwar and stalks of *Pennisetum typhoides*, Kaira, roots of *Lathyrus sativus*, Broach
Phyllosticta althœina Saccardo (9)
On leaves of *Althœa rosea*, Poona

Phyllosticta bauhiniæ Cooke (9)
On leaves of *Bauhinia purpurea*, Bandra
Phyllosticta butleri da Costa and Mundkur (9)
On leaves of *Hoya wightii*, Khandala
Phyllosticta capparidis-heyneanæ da Costa and Mundkur (9)
On leaves of *Capparis heyneana*, Karwar
Phyllosticta combreticola P. Henn. (9)
On leaves of *Combretum ovalifolium*, Dharwar
Phyllosticta dioscoreae Cooke (9)
On leaves of *Dioscorea* sp., Surat
Phyllosticta gastonis Roum. (9)
On leaves of *Musa sapientum*, Arbhavi
Phyllosticta moringicola da Costa and Mundkur (9)
On leaves of *Moringa* sp., Savnur
Phyllosticta myroxyli da Costa and Mundkur (9)
On leaves of *Myroxylon toluiferum*, Poona
Phyllosticta pandanicola Young (9)
On leaves of *Pandanus fascicularis*, Poona
Phyllosticta psoraleæ (Cooke) Tassi (9)
On leaves of *Psoralaea corylifolia*, Poona
Phyllosticta roberti Boy. and Jaecz (9)
On leaves of *Ficus elastica*, Poona
Phyllosticta sedgwickii da Costa and Mundkur (9)
On leaves of *Grewia tiliæfolia*, Dharwar ; Karwar
Phyllostictina tinosporæ Sydow (13)
On leaves of *Tinospora cordifolia*, Ahmedabad
Septoria arcuata Cooke
On leaves of *Ficus retusa*, Poona
Septoria mortolensis Penz.
On leaves of *Acacia arabica*, Vir ; Saswad
Septoria sp.
On leaves of *Garcinia indica*, Konkan
Sphæropsis sp.
On leaves of *Artabotrytis odoratissimus*, Poona

MELANCONIALES

Colletorichum agaves Cav.
On leaves of *Agave* sp., Poona
Colletotrichum curvatum B. and M.
On leaves of *Crotalaria juncea*, Poona
Colletotrichum lindemuthianum (S. and M.) B. and C.
On leaves of *Dolichos lablab*, Poona
Colletotrichum sp.
On leaves of *Albizzia lebbek*, *Albizzia odoratissima*, Poona, *Desmodium diffusum*, Dharwar and *Gossypium herbaceum*, Viramgam
Gloeosporium sp.
On leaves of *Citrus sinensis*, Khandesh, *Pandanus fascicularis*, Poona and *Piper betle*, General
Myxosporium phormii Speg. (13)
On leaves of *Pongamia glabra*, Bombay
Pestalotia guepini Desm.
On leaves of *Lagerstroemia parviflora*, Dharwar

Pestalotia mangalorica Thum.
On leaves of *Bridelia stipularis*, Kanara
Pestalotia menezesiana B. and T.
On leaves of *Leea* sp., Sirsi
Pestalotia versicolor Speg.
On leaves of *Carissa* sp., Karwar
Pestalotia sp.
On leaves of *Achras sapota*, *Loranthus* sp., Poona, *Rosa* sp., Kirkee and *Terminalia paniculata*, Sirsi

MONILIALES

Acrothecium sp.
On leaves of *Ananas comosus*, Kumta
Actinodochium sp. (35)
On *Mangifera indica*, Ratnagiri
Alternaria burnsii Uppal, Patel and Kamat (31)
On aerial parts of *Cuminum cyminum*, Kaira
Alternaria carthami Chowdhury (8)
On leaves of *Carthamus tinctorius*, Deccan
Alternaria radicina Meyer, Drechsler and Eddy
On leaves of *Daucus carota*, Poona
Cercospora achyranthes Sydow
On leaves of *Achyranthes aspera*, Poona
Cercospora calotropidis Ellis and Everhart
On leaves of *Calotropis gigantea*, Khandala
Cercospora chrysanthemi Heald and Wolf
On leaves of *Chrysanthemum* sp., General
Cercospora gossypina Cooke
On leaves of *Gossypium neglectum*, Bhusaval
Cercospora grandissima Rangel
On leaves of *Dahlia* sp., Poona
Cercospora hibisci Tracy and Ellis
On leaves of *Hibiscus cannabinus*, Poona
Cercospora jasminicola Müller and Chupp (14)
On leaves of *Jasminum malabaricum*, Dharwar
Cercospora lathyracearum Heald and Wolf
On leaves of *Punica granatum*, Poona
Cercospora mitteriana Sydow (13)
On leaves of *Dodonea viscosa*, Poona
Cercospora moricola Cooke
On leaves of *Morus alba*, Dharwar
Cercospora sesbaniae P. Henn.
On leaves of *Sesbania grandiflora*, Poona
Cercospora sp.
On leaves of *Careya arborea*, *Cassia tora*, *Colebrookia oppositifolia*, *Impatiens lawii*, *Pavetta indica*, *Petunia* sp. and *Sesbania ægyptica*, Poona
Cercosporella anethi Saccardo
On leaves of *Anethum graveolens*, Poona
Cercosporella leucadis Uppal, Patel and Bhide (41)
On leaves of *Leucas ciliata* and *Leucas stelligera*, Mahableshwar
Cercosporella peristrophes Sydow (13)
On leaves of *Peristrophe bicalyculata*, Poona

Cladosporium calotropidis Stevens
On leaves of *Calotropis gigantea*, Poona

Cladosporium sp.
On leaves of *Daemia extensa*, Poona

Fusarium congulutinans Wr. var. *callistephi* Beach
On roots of *Callistephus chinensis*, Poona

Fusarium orthoceras App. and Wr. var. *lathyri* Bhide and Uppal (1)
On roots of *Lathyrus sativus*, Broach

Fusarium sp.
On roots of *Antirrhinum majus*, Poona

Helminthosporium bicolor Mitra (13)
On roots of *Triticum vulgare*, Bombay

Helminthosporium maydis Nish. and Miyabe
On leaves of *Zingiber officinale*, Poona

Hymenula indica Sydow (13)
On leaves of *Tinospora cordifolia*, Ahmedabad

Oidium chrysanthemi Rabh.
On leaves of *Chrysanthemum* sp., Poona

Oidium cyparissiae Sydow
On leaves of *Euphorbia pilulifera*, Poona

Oidium lini Skoric (14)
On leaves of *Linum usitatissimum*, Dharwar

Oidium piperis Uppal, Kamat, and Patel (39)
On leaves of *Piper betle*, Bassein

Oidium sp.
On leaves of *Abutiton indicum*, *Acalypha ciliata*, *Argemone mexicana*, *Cicer arietinum*, *Clitoria ternatea*, *Crotalaria sinensis*, *Cyamopsis psoraloides*, *Daemia extensa*, *Erythrina indica*, *Impatiens balsamina*, *Ipomœa obscura*, *Lawsonia alba*, *Mirabilis jalapa*, *Momordica charantia*, *Ocimum sanctum*, *Pongamia glabra*, *Salvia* sp. and *Santalum album*, Poona

Piricularia oryzæ Cavara
On leaves, stems and culms of *Oryza sativa*, General

Ramularia mimosae Stev. and Dalz.
On leaves of *Mimosa pudica*, Sirsi

Ramularia sp.
On leaves of *Achyranthes aspera* and *Peristrophe* sp., Poona

Rhizoctonia solani Kühn (12)
On rhizomes of *Ipomœa batata*, Karwar

Sclerotium rolfsii Saccardo
On *Cajanus cajan*, *Papaver somniferum* and *Solanum melongena*, Poona

Sphaceloma fawcetti Jenkins
On leaves and fruits of *Citrus grandis*, Poona

Verticillium dahliae klab (36)
On leaves, stems etc. of *Dahlia* sp., *Datura fastuosa*, *Gossypium herbaceum*, *Hibiscus esculentus*, *Lycopersicum esculentum*, *Nicotiana tabacum*, *Physalis* sp., Poona, *Solanum melongena* and *Solanum tuberosum*, General

Virus
On *Carica papaya* (6) Bombay and Poona, *Datura alba* (4), General, *Dolichos lablab* (3), Poona, *Elettaria cardamomum* (38), Sirsi, *Gossypium herbaceum* (37) *Hibiscus esculentus* (33), *Lagenaria vulgaris* (7), *Phaseolus lunatus* (5), *Phaseolus vulgaris* and *Vigna catjang* (2), Poona

HOST INDEX

Abutilon indicum Sw.
Leveillula taurica
Oidium sp.
Puccinia heterospora.
Acacia arabica Willd.
Fomes badius
Septoria mortolensis
Acalypha ciliata Forsk.
Oidium sp.
Achras sapota L.
Pestalotia sapotæ
Achyranthes aspera L.
Cercospora achyranthes
Ramularia sp.
Actinodaphne hookeri Meiss.
Phyllachora actinodephnes
Agave wightii D. and P.
Diplodia sp.
Agave sp.
Colletotrichum agaves
Albizzia lebbek Benth.
Colletotrichum sp.
Albizzia odoratissima Benth.
Colletotrichum sp.
Althaea rosea L.
Phyllosticta altheinæ
Amaranthus bliti L.
Peronospora amaranthii
Amygdalus persica S. and Z.
Tranzschelia punctata.
Ananas comosus Merr.
Acrothecium sp.
Andropogon annulatus Forsk.
Spacelotheca andropogonis-annulati
Andropogon purpurea var. **sericeus** Hoch.
Tolyposporium ehrenbergii var. grandiglobum.
Anethum graveolens L.
Cercosporella anethi
Anona squamosa L.
Diplodia natalensis
Anthistiria sp.
Sphacelotheca bursa
Antirrhinum majus L.
Fusarium sp.
Arachis hypogaea L.
Mycosphærella arachidicola
Mycosphœrella berkeleyii
Argemone mexicana L.
Oidium sp.
Artabotrytis odoratissimus Br.
Sphæropsis sp.
Arthraxon lanciifolius Hoch.
Bremia graminicola var. indica
Artocarpus integrifolia L.
Rhizopus artocarpi
Avena sativa L.
Ustilago Kolleri
Bambusa sp.
Dasturella bambusiana
Puccinia melanocephala
Bauhinia purpurea L.
Phyllosticta bauhiniæ
Beta vulgaris L.
Bacterium carotovora
Brassica campestris-glauca Roxb.
Xanthomonas campestris
Brassica campestris-rapa L.
Xanthomonas campestris
Brassica juncea (L.) Cosson.
Xanthomonas campestris
Brassica nigra (L.) Koch.
Xanthomonas campestris
Brassica oleracea L.
Xanthomonas campestris
Brassica oleracea-botrytis L.
Bacterium carotovora
Xanthomonas campestris
Brassica oleracea-caulorapa Pasq.
Erysiphe polygoni
Xanthomonas campestris
Bridelia stipularis Bl.
Pestalotia mangalorica
Bridelia retusa Spreng.
Leveillula taurica
Cajanus cajan Millsp.
Leveillula taurica
Sclerotium rolfsii
Callistephus chinensis Ness.
Fusarium conglutinans v. callistephi
Calotropis gigantea R. Br.
Cercospora calotropidis
Cladosporium calotropidis
Canthium umbellata Wight
Meliola asterinoides var. major
Capparis grandis L.
Asterina celtidiola var. capparidis
Capparis heyneana Wall.
Phyllosticta capparidis-heyneanæ
Capparis horrida L.
Asterina celtidiola var. capparidis
Capsicum annuum L.
Bacterium carotovora
Careya arborea Roxb.
Cercospora sp.
Carica papaya L.
Virus
Carissa sp.
Pestalotia versicolor
Carthamus tinctorius L.
Alternaria carthami
Cassia tora L.
Cercospora sp.
Chenopodium album-viride L.
Peronospora effusa
Chrysanthemum sp.
Cercospora chrysanthemi
Oidium chrysanthemi
Puccinia chrysanthemi
Cicer arietinum L.
Oidium sp.
Citrus aurantifolia Sw.
Diplodia natalensis
Meliola butleri
Citrus grandis (L.) Osbeck
Diplodia natalensis
Sphaceloma fawcetti

Citrus nobilis var. **deliciosa** (T.) Sw.
Diplodia natalensis
Citrus sinensis Osbeck
Bacterium carotovora
Diplodia natalensis
Gloeosporium sp.
Sphaceloma fawcetti
Xanthomonas citri
Citrus sp.
Capnodium citri
Clarkia elegans Dougl.
Phytophthora parasitica
Clitorea ternatea L.
Oidium sp.
Cocos nucifera L.
Diplodia epicocos
Coix lachryma jobi L.
Puccinia operta
Colebrookia oppositifolia Sm.
Cercospora sp.
Combretum ovalifolium Roxb.
Phyllosticta combreticola
Commelina forskaloei Vahl.
Uromyces commelinæ
Cosmos sp.
Sphaerotheca humuli
Crinum asiaticum L.
Aecidium crini
Crotalaria juncea L.
Colletotrichum curvatum
Leveillula taurica
Crotalaria rustica L.
Uromyces decoratus
Crotalaria sinensis L.
Oidium sp.
Crotalaria usuramoensis Baker
Leveillula taurica
Cucumis sativus L.
Bacterium carotovora
Cuminum cyminum L.
Alternaria burnsii
Cyamopsis psoraloides DC.
Oidium sp.
Daemia extensa Br.
Cladosporium sp.
Oidium sp.
Dahlia sp.
Cercospora grandissima
Verticillium dahliae
Datura alba L.
Virus
Datura fastuosa L.
Verticillium dahliae
Daucus carota L.
Alternaria radicina
Bacterium carotovora
Desmodium diffusum DC.
Colletotrichum sp.
Xanthomonas desmodii
Desmodium gangeticum DC.
Xanthomonas desmodii-gangeticii
Dicanthium annulatum Forsk.
Sphacelotheca annulati
Dimeria ornithopoda Trin.
Phyllachora indica
Dioscorea sp.
Phyllosticta dioscoreæ
Diospyros melanoxylon Roxb.
Aecidium rhytismoides
Dodonea viscosa L.
Cercospora mitteriana
Dolichos lablab L.
Colletotrichum lindemuthianum
Leveillula taurica v. macrospora
Xanthomonas phaseoli-indicus
Virus
Dolichos biflorus L.
Xanthomonas phaseoli-sojense
Elettaria cardamomum Maton.
Virus
Eleusine coracana Gaert.
Melanopsichium eleusinis
Erythrina indica Lam.
Oidium sp.
Euchlaena mexicana Schr.
Sclerospora sorghi
Euphorbia pilulifera L.
Oidium cyparissiæ
Evolvulus alsinoides
Cystopus evolvulæ
Ficus elastica Roxb.
Phyllachora repens
Ficus religiosa L.
Phyllachora repens
Ficus retusa L.
Septoria arcuata
Flacourtia sp.
Masseeella capparidis
Garcinia indica Chois.
Septoria sp.
Glycine soja S. and Z.
Xanthomonas phaseoli var. sojense
Gossypium arboreum
Cercospora gossypina
Leveillula taurica
Gossypium herbaceum L.
Colletotrichum sp.
Verticillium dahliae
Virus
Gossypium hirsutum L.
Phytophthora parasitica
Xanthomonas malvacearum
Grewia tiliaefolia Vahl.
Phyllosticta sedgwickii
Gymnosporia rothiana
Uredinella spinulosa
Gynandropsis pentaphylla DC.
Leveillula taurica
Helianthus annuus L.
Erysiphe cichoracearum
Heterophragma roxburghii DC.
Phragmidiella heterophragmæ
Hibiscus cannabinus L.
Cercospora hibisci
Hibiscus esculentus L.
Bacterium carotovora
Verticillium dahliae
Virus
Hoya wightii Hook.
Phyllosticta butleri
Impatiens balsamina L.
Leveillula taurica
Oidium sp.

Impatiens lawii H. and T.
Cercospora sp.
Ipomoea batata L.
Bacterium carotovora
Macrophomina phaseoli
Rhizoctonia solani
Ipomoea muricata R. and Sch.
Xanthomonas uppalii
Ipomoea obscura Kerr.
Oidium sp.
Jasminum malabaricum W.
Cercospora jasminicola
Justicia gendarussa Ness.
Puccinia thwaitesii
Justicia simplex D. Don.
Plasmopara wildemaniana
Lagenaria vulgaris Ser.
Virus
Lagerstroemia parviflora Roxb.
Pestalotia guepini
Lathyrus sativus L.
Fusarium orthoceras var. lathyri
Macrophomina phaseoli
Lawsonia alba Lam.
Oidium sp.
Leea sp.
Pestalotia menezesiana
Leucas ciliata Benth.
Cercosporella leucadis
Leucas stelligera Wall.
Cercosporella leucadis
Linum usitatissimum L.
Oidium lini
Loranthus sp.
Pestalotia sp.
Lycopersicum esculentum Mill.
Bacterium carotovora
Leveillula taurica
Phytophthora parasitica
Verticillium dahliae
Malus sylvestris Mill.
Diplodia natalensis
Phytophthora parasitica
Mangifera indica L.
Actinodaphne sp.
Bacterium carotovora
Diplodia natalensis
Dothiorella sp.
Macrophoma sp.
Pseudomonas mangiferæ-indicæ
Martynia diandra Glox.
Leveillula taurica
Medicago sativa L.
Leveillula taurica
Mimosa pudica L.
Ramularia mimosæ
Mirabilis jalapa L.
Oidium sp.
Momordica charantia L.
Oidium sp.
Moringa sp.
Phyllosticta moringicola
Morus alba L.
Cercospora moricola
Phyllactinia corylea
Cerotelium fici
Musa sapientum L.
Bacterium carotovora
Phyllosticta gastonis
Myroxylon tolniferum L.
Phyllosticta myroxyli
Nasturtium sp.
Leveillula taurica
Nicotiana tabacum L.
Verticillium dahliae
Ocimum sanctum L.
Oidium sp.
Olea dioica Roxb.
Cystopsora oleæ
Stephanotheca oleæ
Opuntia sp.
Phytophthora parasitica
Oryza sativa L.
Capnodium sp.
Piricularia oryzæ
Pandanus fascicularis Lam.
Glœosporium sp.
Phyllosticta pandanicola
Papaver somniferum L.
Erysiphe cichoracearum
Sclerotium rolfsii
Pavetta indica L.
Aecidium pavettæ
Cercospora sp.
Pennisetum purpureum Schum.
Sclerospora graminicola
Pennisetum typhoides Stap. and Hubb.
Tilletia ajrekeri
Macrophomina phaseoli
Peristrophe bicalyculata Ness.
Cercosporella peristrophes
Ramularia sp.
Petunia sp.
Cercospora sp.
Phaseolus coccineus Jacq.
Xanthomonas phaseoli indicus
Phaseolus lunatus L.
Virus
Xanthomonas phaseoli indicus
Phaseolus mungo v. **radiatus** L.
Erysiphe polygoni
Phaseolus vulgaris L.
Bacterium carotovora
Virus
Xanthomonas phaseoli var. indicus
Xanthomonas vignicola
Physalis sp.
Verticillium dahliae
Piper betle L.
Capnodium betle
Glœosporium sp.
Oidium piperis
Piper trichostachyon Cass.
Capnodium betle
Pisum sativum L.
Bacterium carotovora
Polygonum chinense L.
Liroa emodensis
Puccinia solmsii
Polytoca barbata Stapf.
Ustilago polytocæ

Pongamia glabra Vent.
Myxosporium phormii
Oidium sp.
Prunus communis (L.) Fri.
Diplodia natalensis
Psidium guyava L.
Phytophthora parasitica
Psoralea corylifolia L.
Phyllosticta psoraleæ
Punica granatum L.
Cercospora lathyracearum
Diplodia natalensis
Raphanus sativus v. **caudatus** L.
Peronospora parasitica
Bacterium carotovora
Xanthomonas campestris
Rhynchosia minima DC.
Uromyces dolicholi
Ricinus communis L.
Phytophthora parasitica
Rivea sp.
Trochodium riviæ
Rosa multiflora Thum.
Diplocarpon (Actinonema) rosæ
Ruellia prostrata Lasik.
Puccinia ruelliæ
Rumex vesicarius L.
Uromyces rumicis
Salvia sp.
Oidium sp.
Santalum album L.
Oidium sp.
Sesamum indicum L.
Leveillula taurica
Phytophthora parasitica
Sesbania aegyptica Poir.
Cercospora sp.
Erysiphe polygoni
Sesbania grandiflora Poir.
Cercospora sesbaniæ
Smithia bigemina Dalz.
Parodiella smithiæ
Solanum melongena L.
Phyllachora hortorum
Phytophthora parasitica
Sclerotium rolfsii
Verticillium dahliae
Solanum tuberosum L.
Bacterium carotovora
Leveillula taurica
Phytophthora parasitica
Verticillium dahliae
Stizolobium deeringianum Bort.
Uromyces mucunæ
Tagetes sp.
Leveillula taurica
Tectona grandis L.
Olivea tectonæ
Terminalis paniculata Roth.
Pestalotia sp.
Tinospora cordifolia Miers.
Hymenula indica
Mycosphærella tinosporæ
Phyllostictina tinosporæ
Triticum vulgare Vill.
Helminthosporium bicolor
Verbena sp.
Erysiphe cichoracearum
Vernonia cinerea Less.
Plasmopara halstedii
Vigna catjang Walp.
Bacterium carotovora
Erysiphe polygoni
Virus
Xanthomonas vignicola
Vigna sesquipedalis Wight
Xanthomonas vignicola
Vigna sinensis (L.) Endl.
Xanthomonas vignicola
Vitis vinifera L.
Diplodia viticola
Zea mays L.
Sclerospora sorghi
Physoderma maydis
Zingiber officinale Rosc.
Helminthosporium maydis
Pythium myriotylum
Zizyphus jujuba Lam.
Erysiphe acaciæ
Phakopsora zizyphi-vulgaris

REFERENCES

1. Bhide, V. P. & Uppal, B. N. (1948) .. A new *Fusarium* disease of lang (*Lathyrus sativus*) *Phytopathology* **38** : 560-567
2. Capoor, S. P., Varma, P. M. & Uppal, B. N. (1947) .. A mosaic disease of *Vigna catjang* Walp. *Curr. Sci.* **16** : 151
3. Capoor, S. P. & Varma, P. M. (1948) .. A mosaic disease of *Dolichos lablab* Linn., a new virus disease. *Curr. Sci.* **17** : 57
4. ..... (1948) .. A mosaic disease of *Datura alba* Nees. *Curr. Sci.* **17** : 151
5. ..... (1948) .. Yellow mosaic of *Phaseolus lunatus* L. *Curr. Sci.* **17** : 152
6. ..... (1948) .. A mosaic disease of *Carica papaya* L., in the Bombay Province. *Curr. Sci.* **17** : 265
7. ..... (1948) .. A mosaic disease of *Lagenaria vulgaris* Ser. in the Bombay Province. *Curr. Sci.* **17** : 274
8. Chowdhury S. (1944) .. An *Alternaria* disease of safflower. *J. Indian Bot. Soc.* **23** : 59-65
9. De Costa G. C. & Mundkur, B. B. (1948) .. A revision of the genus *Phyllosticta* in India. *Proc. Nat. Inst. Sci.* (India), **14** : 55-63
10. Diwan N. D. (1948) .. Bacterial blight of cowpea. Thesis for M. Sc. of Bombay University (Unpublished)
11. Kamat, M. N. & Patel, M. K. (1948). .. Some new hosts of *Oidiopsis taurica* (Lev.) Salmon in Bombay. *Indian Phytopathology.* **1** : 153-158
12. Mundkur, B. B. (1936) *Rhizoctonia* on sweet potatoes in Bombay. *Indian J. Agric. Sci.* **6** : 994-995
13. ..... (1938) .. Fungi of India. Supplement I. I. *Coun. Agric. Res. India, Sci. Monograph* No. 12
14. ..... & Thirumalachar, M. J. (1946) Revisions of and addition to Indian Fungi. I. *Imp. Mycol. Inst. Mycol. Papers.* No. 16
15. ..... (1945) .. Two new genera of rusts on Bignoniaceae. *Mycologia* **37** : 619-628
16. Parandekar, S. A. (1936) A note on a few rusts from Kolagaon (Nagar Dist.). *Curr. Sci.* **5** : 228
17. Patel, M. K. (1948) .. A note on *Bremia* found on *Arthraxon lancifolius* Hoch. in India. *Indian Phytopathology* **1** : 104-106
18. ..... (1948) .. *Xanthomonas Uppalii* sp. nov., pathogenic on *Ipomoea muricata. Indian Phytopathology* **1** : 67-69
19. Patel, M. K. & Moniz, L. (1948) .. Bacterial leaf spot of *Desmodium gangeticum* DC. *Indian Phytopathology* **1** : 137-141
20. ..... & Kulkarni, Y. S. (1948) .. *Xanthomonas malvacearum* (Sm.) Dowson on exotic cottons in India. *Curr. Sci.* **17** : 243-244
21. ..... , ..., & Dhande, G. W. (1949) .. *Dolichos biflorus* L. A new host of *Xanthomonas phaseolisojense* Hedges *Curr. Sci.* **18** : 83-84

22. ....., ..., & Moniz, L (1948)	*Pseudomonas mangiferæ-indicæ* on mango. *Indian Phytopathology* **1** : 147-152
23. ..... & Padhye, Y. A. (1949)	Bacterial soft rot of mango in Bombay. *Indian Phytopathology* **2** : 127-128
24. ..... , Kulkarni Y. S. & Abhyankar, S.G. (1949)	Black rot of cabbage in Bombay. *Indian Phytopathology* **2** : 58-61
25. ..... (1949)	Production of oospores by *Sclerospora sorghi* on maize. *Indian Phytopathology* **2** : 52-57
26. Sawada K. (1919)	Descriptive catalogue of the Formosan fungi. *Agric. Exp. Sta. Spec. Bull.* **19**
27. Thirumalachar, M. J. (1950)	*Proc. Ind. Sci. Congress.* 1950.
28. ..... & Mundkur, B. B. (1950)	Revisions of and additions to Indian fungi. III *Mycol. paper, Common. Mycol. Inst.* (in press)
29. Uppal, B. N., Patel, M. K. & Kamat, M. N. (1936)	The Fungi of Bombay. *Dep. Agric. Bom. Bull.* 176
30. ..... , Kamat, M. N. & Patel, M. K. (1936)	A new variety of *Oidiopsis taurica. Indian J. Agric. Sci.* **6** : 110-115
31. ..... , Patel, M. K. & Kamat, M.N. (1938)	*Alternaria* blight of cumin. *Indian J. Agric. Sci.* **8** : 49-62
32. ..... , ... & ..... (1938)	Bacterial leaf spot of soya bean in Bombay. *J. Uni., Bom.* **6** : 16-18
33. ..... , Varma, P. M. & Capoor, S. P. (1940)	Yellow mosaic of bhendi. *Curr. Sci.* **9** : 227
34. ..... , & Patel, M. K. (1943)	Long smut of *Sorghum purpureo sericeum. Indian J. Agric. Sci.* **13** : 520-521
35. ..... (1943)	Ann. Rep. Dep. Agric. Bombay, 1941-42 : 125
36. ..... (1944)	Ann. Rep. Dep. Agric. Bombay, 1942-43
37. ....., Capoor, S. P. & Raychaudhari, S. P. (1944)	Small leaf disease of cotton. *Curr. Sci.* **13** : 284
38. ....., Varma, P.M. & Capoor, S. P. (1945)	A mosaic disease of cardamom. *Curr. Sci.* **14**: 208
39. ....., Kamat, M. N. & Patel, M. K. (1946)	Powdery mildew of betle vine. *Proc. Indian Acad. Sci.* **24** : 255-259
40. Uppal, B. N., Patel, M. K. & Nikam, B. G. (1946)	Bacterial blight of *Phaseolus vulgaris.* var. white kidney. *Proc. Nat. Inst. Sci.*, (India), **12** : 351-359
41. ..... , ... &	Four new species of Fugi from Bombay *Indian Phytopathology*: **2** : 176-179

Plant Pathological Laboratory,
College of Agriculture,
Poona, India

NOTES ON TWO FUNGI PARASITIC ON SCALE INSECTS

By M. J. THIRUMALACHAR.

(Accepted for publication July 30, 1949)

COLLECTIONS of a fungus on the leaves of *Gymnosporia ovata* Lawson (Celastraceae) by Rev. Father Dr. H. Santapau in Khandala, Bombay proved on examination to be of great interest. The fungus was encrusting scale insects on the lower surface of the leaves, forming purplish-brown patches. The insects were killed by the fungus, the mycelium radiating on the sides to form delicate crusts. A detailed examination revealed the fungus to be a species of *Uredinella*, a remarkable genus described by Couch (1937), parasitising scale insects and having characters intermediate between the plant rusts and *Septobasidium*.

Two species of *Uredinella* are so far known; *U. coccidiophaga* Couch which is the type of the genus, found on scale insects in South Carolina and Florida in the United States of America, and *U. spinulosa* Couch and Petch on *Aspidiotus* (scale insect) in Ceylon (Couch 1941). The latter species was collected by Petch on scale insects infecting the leaves of *Psychotria* sp. Comparative studies indicate that the *Uredinella* species collected in Khandala resembles in all essential features *U. spinulosa* and is therefore referred to that species.

There is one parasitised scale insect beneath each fungal patch which is 1 to 2 mm. in diameter. In texture the fungal patches are firm, brittle and show an elevation in the centre due to the presence of the remains of the insect (Fig. 1). As regards the dimensions, sections through the central region of the insect are up to 300μ thick and there is a gradual thinning out on the sides towards the margin (Fig. 3). The basal subiculum is composed of septate brownish hyphae which traverse in a radial manner. The hymenium shows a single layer of spores on the margin and more than two to three layers towards the centre. Unlike *U. coccidiophaga*, the region of the stroma above the insect is not sterile, but bears numerous spores.

As pointed out by Couch (1937 and 1941) the hymenial cells are composed of two types of cells; the teliospores which are obovate to ellipsoid, are always borne on a persistent pedicel (Fig. 4); and somewhat teliospore-like cells which intergrade closely with the teliospores developed from a dicaryotic mycelium and are without distinct stalk cells (Fig. 2). Couch (1937) carried out cytological studies in *U. coccidiophaga* and found that the teliospores developed from a dicaryotic mycelium and possessed syncaryotic fusion nucleus. On germination a typical basidium was formed as in rusts, bearing basidiospores on sterigmata. On the other hand, the teliospore-like hymenial cells showed throughout only binucleate condition and on germination produced a binucleate allantoid spore body, which Couch was inclined to consider as comparable with the urediospores of rusts.

Similar cytological studies were not carried out in the present study, since only herbarium material was available. However in lactophenol mounts of the material, some of the germination stages of the teliospores and the elongated teliospore-like hymenial cells have been observed (Figs. 2 and 6). The basidium is four-celled (Fig. 6) bearing short sterigmata. Proliferation of new teliospores within old ones (Fig. 5) has been observed in several instances similar to those reported by Couch.

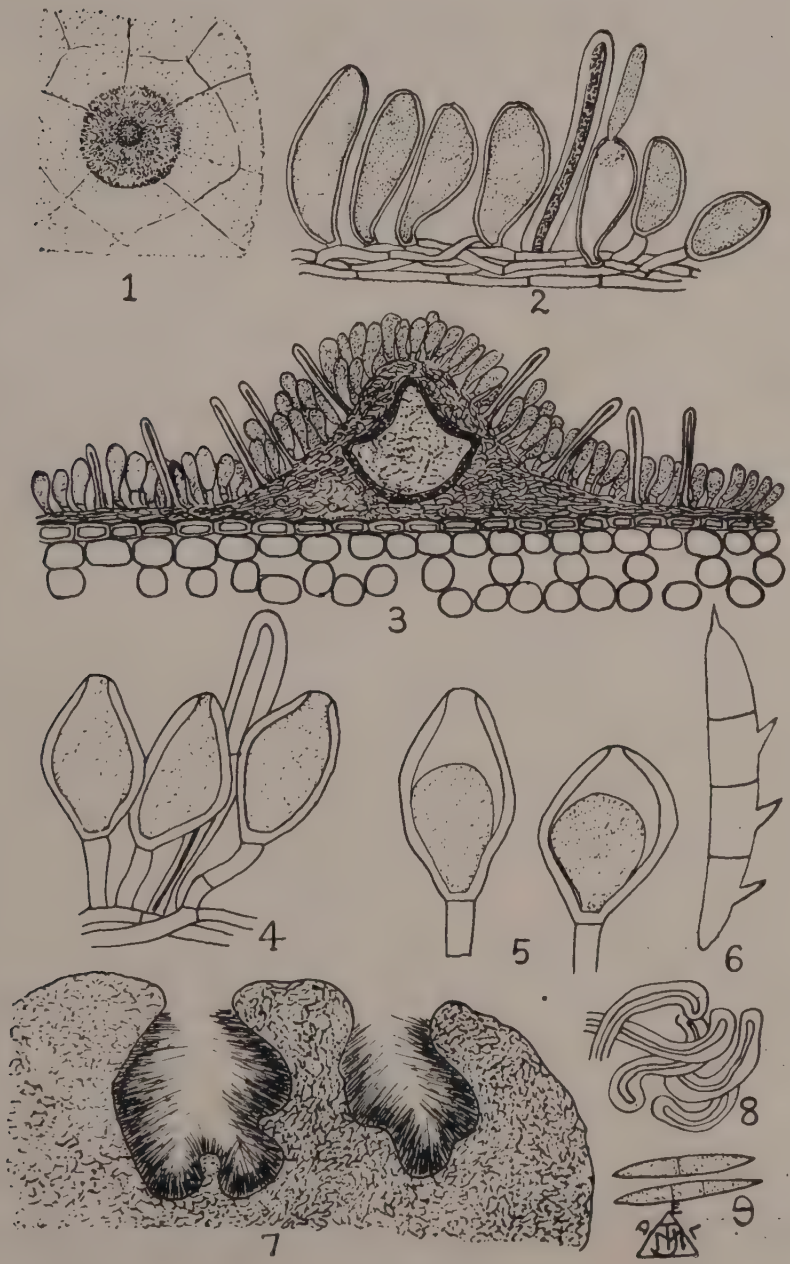


Fig. 1—9. Uredinella spinulosa. See text for explanation of figures

In the character of the hymenial cells and the development of numerous setae, the fungus under study closely resembles *U. spinulosa*. The setae are reddish-brown with a central core (Fig. 2), measuring mostly up to 80μ and therefore slightly smaller than those described for the Ceylon form.

An entomogenous fungus parasitising Aleyrodid insects on the leaves of *Murraya exotica* (Rutaceae) and *Trema orientalis* (Ulmaceae) collected in Nandi Hills, Mysore, was found on examination to be a species of *Aschersonia*. The stromata are hard, flattened up to 2.5 mm. in diameter and orange-yellow in the centre and white along the margins. The hypothallus is broad with strands of radiating hyphae which appear whitish in colour. The stroma is composed of densely interwoven mass of hyphae which are coarse, thick-walled with small lumen in the centre (Fig. 8).

The pycnidia are large, deeply sunk in the stroma (Fig. 7), ostiolate, which become wide in later stages. When two or more pycnidia develop in close proximity, they coalesce and form a single unilocular pycnidium. The pycnosporophores line the base and the sides of the pycnidia and form in succession fusiod pycnospores acrogenously. Long filiform paraphyses measuring up to 125 μ are associated with the pycnosporophores and these are considered by Petch (1914) to be characteristic of the aleyrodiicolous species of *Aschersonia*. The pycnospores are orange-yellow in mass, fusoid, with acute ends, 10-15 x 1-1.5 μ and often becoming spuriously one-septate (Fig. 9).

The pycnospores germinate readily when placed on water agar developing branched germ tubes. Single germinating spores were transferred on to potato dextrose agar aseptically. The fungus grows rather slowly on potato dextrose agar and malt agar, showing a fluffy white arachnoid type of mycelial growth. The fundaments of the stroma are first formed as aggregates of mycelial strands. Mature stromata bearing the orange coloured pycnidia and pycnospores are observed in culture 30 days after incubation at room temperature (20-24°C). Further studies are being made to secure more rapid growth of the fungus in culture for using it for artificial inoculation of the insects.

As regards the identity of the fungus, it resembles very closely *Aschersonia papillata* described by Petch (1925) from Ceylon on Aleyrodid insects infesting *Citrus*. The pycnidia of this are paraphysate and the spores measure 12-16 x 1-1.5μ, often becoming spuriously one-septate. Two species of *Aschersonia* are so for known in India. *A. badia* Pat. on scale insects of bamboo leaves in Burma (Butler & Bisby 1931) and *A. coffeae* P. Henn. a lecaniicolous species reported on unknown leaves in Darjeeling by Sydow and Mitter (1933).

Grateful thanks are due to Rev. Father Dr. H. Santapau, for the specimens of *Uredinella*.

Malleswaram
Bangalore

REFERENCES

Butler, E. J. and Bisby, G. R. (1931) .. .. Fungi of India. *Sci. Monogr. Coun. Agric. Res. India*, 1, p. 151

Couch, J. N. (1937) .. A new fungus intermediate between the rusts and *Septobasidium*. *Mycologia* **29** : 665-673

„ (1941) .. .. A new *Uredinella* from Ceylon. *Mycologia* **33** : 405-410

Petch, T. (1914) .. .. The genera *Hypocrella* and *Aschersoni*. *Anna. R. Bot. Peradeniya* **5** : 521-537

„ (1925) .. .. Entomogenous fungi: Additions and Corrections *Trans. Brit. Mycol. Soc.* **10** : 190-201

Sydow, H. and Mitter, J. H. (1933) .. .. .. Fungi Indici I. *Ann. Mycol.* **31** : 84-97

EXPLANATION OF FIGS.

Figs. 1 to 6 *Uredinella spinulosa*

Fig. 1. small dark rounded patches of the fungus x 20

Fig. 2. Hymenia with setae and telioospore-like cells x 600

Fig. 3. Section through the part of the fungal patch including the scale insect x 200

Fig. 4. Teleutospores x 900

Fig. 5. Showing proliferation within the teliotospores x 900

Fig. 6. Basidium x 750.

Figs. 7 to 9. *Aschersonia papillata*

Fig. 7. Sections through stroma showing pycnidia x 400

Fig. 8. Thick walled hyphae composing the stroma x 1500

Fig. 9. Pycnospores showing spurious septation x 2000

PARTIAL VITAMIN DEFICIENCIES IN FOUR STRAINS OF COLLETOTRICHUM LINDEMUTHIANUM[1]

By R. S. MATHUR, VIRGIL GREENE LILLY AND H. L. BARNETT

(Accepted for publication Aug. 3, 1949)

MANY fungi are able to synthesize the vitamins necessary for growth and reproduction, while others grow poorly or not at all without an exogenous supply of one or more of the needed vitamins. Between these two classes, the *self sufficient* and the *completely deficient*, there are many fungi which, though able to synthesize the necessary vitamins from the nutrient solutions, do so too slowly to allow the maximum rate of growth. Such fungi are classed as *partially deficient* and their growth rate is increased by the addition of the needed vitamins. Both complete and partial deficiencies may be single (for one vitamin) or multiple (for more than one vitamin). The deficiency may be absolute, when environmental conditions have no effect upon the synthesis of vitamins by the organism. It may be *conditioned*, when a vitamin deficiency may be modified by changes in environment.

Our knowledge concerning vitamin deficiencies of many known species of fungi has been well summarized by Robbins and Kavanagh (9). However, comparatively little is known about the vitamin deficiencies of strains within the same species. Lilly and Barnett (7) noted differences in vitamin deficiencies between 2 isolates of *Botryotinia convoluta*, 4 isolates of *Ciboria acerina* and 2 isolates of *Stromatinia smilacinae*. Hawker (4) found some strains of *Melanospora destruens* to be self sufficient for biotin while others were biotin deficient.

The vitamin deficiencies of *Colletotrichum lindemuthianum* (Sacc. and Magn.) Bri. and Cav. have apparently not been fully studied. Ronsdorf (10) grew this fungus in a mineral-sucrose solution containing KNO_3 and found that the addition of a bios preparation from yeast had little effect. It seemed desirable to investigate further the vitamin requirements of several isolated of *C. lindemuthianum*.

Materials and Methods

One isolate each of the *alpha*, *beta* and *gamma* strains of *C. lindemuthianum* was obtained from Cornell University through the courtesy of Dr. W. H. Burkholder. Another isolate of this fungus was made from anthracnose lesions on bean pods collected from Preston County, West Virginia, by Mr. E. S. Elliott. These fungi will be designated as the *alpa*, *beta*, *gamma*, and the *Preston County* isolates.

Throughout the investigation, vitamin-free casein hydrolysate medium (6), adjusted to pH 6.0 before autoclaving was used as the basal medium. The vitamins were added to this medium at the following rates per liter: thiamin, 100mg., pyridoxine, 100 μg., inositol, 5 μg., and biotin, 5 μg. These solutions were distributed in 250 ml. Erlenmeyer flasks, at the rate of 25 ml. per flask. Medium without vitamins was used as control. The media were autoclaved at 120°C. for 15 minutes. The pH of the medium after autoclaving was 5.3.

---

1 Published with the approval of the Director of the West Virginia Agricultural Experiment Station as Scientific Paper No. 407.

The inoculum was prepared by growing the different isolates in one per cent malt extract solution for two to three weeks. The excess of the liquid was drained off and each mycelial colony was transferred aseptically to a sterile Waring blendor (11). The colonies were blended in 50 ml. sterile water for 30 seconds and a drop of the minced mycelium was used to inoculate each flask. The inoculated flasks were incubated at 25°C.

Another experiment was designed to study the influence of temperature on the partial vitamin deficiencies of a single spore culture derived from the *gamma* isolate. The procedure of preparing media and inoculation of flasks was the same as described above. The inoculated flasks were incubated at 15°, 20°, 25°, and 30°C.

Sufficient number of flasks were inoculated in each experiment so that three or more harvests of each treatment could be taken. The period of incubation was sufficiently long to ensure the validity of the conclusions. Growth is reported as milligrams of mycelium (oven dried at 90°C. to constant weight after each harvest). Each value reported is the average weight of 2 cultures and only relevant data are presented. All experiments were repeated twice.

Experimental

Vitamin deficiencies of the alpha, beta, gamma and the Preston County isolates

These isolates were tested for possible deficiencies of thiamin, pyridoxine, inositol and biotin. The following conclusions can be derived from the data given in table 1.

The *alpha* isolate is partially deficient for thiamin since the rate and amount of early growth were increased in the presence of this vitamin. Inositol appeared to be without effect, but pyridoxine and biotin depressed growth somewhat towards the end of the experiment. It can be noted from Table I that the combination of four vitamins induced slightly more growth than any other condition.

Growth of the *beta* isolate was depressed by thiamin and to a lesser extent by pyridoxine. Biotin and inositol singly were essentially without effect. The combination of four vitamins depressed growth after the seventh day of incubation. Note the difference in behaviour between the *alpha* and *beta* isolates. The effect of these four vitamins on growth of the *gamma* isolate was still different. Biotin stimulated early growth. This isolate is, therefore, partially deficient for this vitamin. Pyridoxine alone was without effect, while thiamin and the four vitamin combination depressed growth just as they did for the *beta* isolate.

The response of the *Preston County* isolate to these vitamins was still different. Pyridoxine, inositol and biotin increased early growth. This isolate is, therefore, partially deficient for these three vitamins. Thiamin alone and the four-vitamin combination depressed growth of this isolate.

TABLE I

The effect of vitamins on the growth of the alpha, beta, gamma *and* Preston County *isolates of* C. lindemuthianum *in casein hydrolysate medium at 25°C.*

Isolate	Days of incubation	Control mg.	Thiamin mg.	Pyridoxine mg.	Inositol mg.	Biotin mg.	4 vitamins together mg.
alpha ..	4	9	6	3	2	6	10
	7	26	42	12	22	21	49
	12	67	142	49	76	62	70
	16	163	169	136	177	100	194
beta ..	4	6	9	5	25	8	43
	7	22	30	24	38	36	52
	12	75	40	77	73	80	60
	16	133	43	83	167	142	50
gamma ..	6	12	8	9	16	26	25*
	9	35	24	33	44	117	105
	14	109	54	94	140	204	34
	18	185	36	173	174	190	28
Preston County	10	24	18	116	79	71	64
	15	169	37	211	191	207	24

* This value is not consistent with the other results.

Effect of vitamins and temperature on the growth of the gamma isolate

Several workers (3, 5) have shown that *C. lindemuthianum* is sensitive to high temperature. An experiment was designed to determine if incubation at different temperatures had any effect on its response to thiamin, inositol and biotin. The relevant data are presented in Table II. In general, the rate of growth was less at 15° than at 20° or 25°C. The one exception seems to be those cultures containing added thiamin, inositol and biotin. The striking effect of the three vitamin combination did not appear when the cultures were incubated at higher temperatures. These experiments confirmed the inhibiting effect of thiamin, although at 15°C. this effect did not appear until after the eleventh day of incubation. The partial deficiencies of this isolate for inositol and biotin were demonstrated for all temperatures employed. In addition it should be noted that either inositol or biotin when used in conjunction with thiamin overcame the inhibitory effect of this vitamin. From this behaviour we may deduce that the effect of a given vitamin upon a fungus is conditioned by the presence or absence in the medium of other vitamins.

Growth was poor at 30°C. under all vitamin treatments tried. It is noteworthy that the presence of the vitamins (except thiamin alone) increased growth at this temperature. However, growth could not be considered "normal" at this temperature irrespective of the vitamins added to the medium.

TABLE II

The effect of temperature upon rate of growth of the gamma *isolate of* C. lindemuthianum *in the presence of certain vitamins. Harvested after 5 and 11 days incubation*

Vitamins added	Temperature						
	15° C.		20° C.		25° C.		30° C.
	5 days mg.	11 days mg.	5 days mg.	11 days mg.	5 days mg.	11 days mg.	21 days mg.
Control (none added) ..	10	56	11	140	17	122	17
Thiamin	10	56	7	63	10	62	16
Inositol	5	73	19	151	47	152	35
Biotin	4	90	18	125	28	108	44
Thiamin and inositol ..	7	86	25	150	22	134	38
Thiamin and biotin ..	8	127	37	176	22	165	29
Inositol and biotin ..	9	98	26	106	33	121	50
Thiamin, inositol and biotin	21	202	43	138	56	171	29

* Because of the slow rate of growth at 30°C., only the data for the harvest after 21 days incubation is reported.

DISCUSSION

These experiments show that the different strains of *C. lindemuthianum*, known to vary in pathogenicity, also differ in partial deficiencies for vitamins. Probably there is no correlation between their partial deficiencies for vitamins and pathogenicity.

Partial deficiencies for vitamins are common among fungi. Burkholder and Moyer (2) recently found several yeasts to have varying degrees of partial inositol deficiency.

With regard to the depressing effect of thiamin on the *beta*, *gamma* and *Preston County* isolates, there are many parallel examples in literature. Lilly and Barnet (8) reported a similar phenomenon at certain pH values with *Sordaria fimicola* and Wirth and Nord (13) with *Fusarium lini*. Schopfer and Guillound (12) found that the depression of growth of *Rhizopus suinus* caused by thiamin was overcome by inositol.

Since the effect of inositol and biotin, and especially the vitamin combinations was greatest at 15°C. it may be supposed that the slow rate of growth of the control cultures at this temperature was due to limited synthesis of these and other growth factors. Barnett and Lilly (1) found that added inositol increased the rate of growth of *Sclerotinia camelliae* as the temperature of incubation increased to 26°C; thereafter, inositol inhibited the growth of this fungus.

Some investigators (3, 5) have reported 30°C. to be above the optimum for *C. lindemuthianum*. This was confirmed in the present investigation. At 30°C. the addition of inositol or biotin or both significantly increased growth. However, the addition of these vitamins did not allow "normal" growth.

SUMMARY

The effects of thiamin, biotin, inositol and pyridoxine, singly and in combination of the 4 vitamins on the growth of four isolates of *C. lindemuthianum*, were studied.

All isolates tested were partially deficient for one or more vitamins. The *alpha* isolate was partially deficient for thiamin, the *beta* isolate had a very weak partial deficiency for biotin, and the *gamma* isolate for inositol and biotin while the *Preston County* isolate was partially deficient to pyridoxine, inositol and biotin. Thiamin alone was depressing for the *beta*, *gamma* and *Preston County* isolates.

The effect of biotin and inositol, and especially combinations of these vitamins with thiamin appeared to be greater at 15° than at 20°, 25° or 30°C. Biotin and inositol did have some favourable effect on growth at 30°C, but growth was not "normal" even when these vitamins were added to the medium.

Department of Plant Pathology and Bacteriology
West Virginia University
Morgantown, West Virginia

REFERENCES

1. Barnett, H. L. and V. G. Lilly. 1948 The interrelated effects of vitamins, temperature, and pH upon the vegetative growth of *Sclerotinia camelliae*. *Amer. J. Bot.* **35** : 297-302

2. Burkholder, P. H. and Dorothy Moyer. 1943 Vitamin deficiencies of fifty yeasts and molds. *Bull. Torrey Bot. Cl.* **70** : 372-377

3. Edgerton, C. W. 1915 .. Effect of temperature on *Glomerella*. *Phytopathology* **5** : 247-259

4. Hawker, L. E. 1933 .. .. The nature of the accessory growth factors influencing growth and fruiting of *Melanospora destruens* Shear, and of some other fungi. *Ann. Bot.* N. S. **3** : 657-676

5. Leach, J. G. 1923 .. .. The parasitism of *Colletotrichum lindemuthianum*. *Tech. Bull. Minn. Agric. Exp.* Sta. **14**. 41 pp. illus.

6. Leonian, L. H. and V. G. Lilly. 1945 The comparative value of different test organism in the microbiological assay of B vitamins. *Bull. West Va Agric. Exp. Sta.* **319**

7. Lilly, V. G. and H. L. Barnett 1948 Growth rates and vitamin deficiencies of various fungi. Proc. W. Va Acad. Sci. (1947). *W. Va University Bul Ser.* **49** III-4. 27-33

8. 1947. . The influence of pH and certain growth factors on mycelial growth and perithecial formation by *Sordaria fimicola*. *Amer. J. Bot.* **34**: 131-138

9. Robbins, W. J. and V. Kavanagh. 1942 Vitamin deficiencies of the filamentous fungi. *Bot. Rev.* **3**: 411-471

10. Ronsdorf L. 1935 ..Vergleichande Unterschungen über die Wirkung verschiedener Wuchsstoffe auf das Wachstum einiger Pilze. *Arch. Mikrobiol.* **6**: 309-325

11. Savage, G. N. and M. J. Vanderbrook. 1946 The fragmentation of the mycelium of *Penicillium notatum* and *Penicillium chrysogenum* by a speed blendor and the evaluation of blended seed. J. *Bact.* **52**: 385-391

12. Schopfer, W. H. and M. Guilloud. 1945 Recherches experimentales sur les facteurs de Croissance et le pourvoir de synthese de *Rhizopus cohnii* Berl. et de Toni (*Rhizopus suinus Nielsen.*). *Zeitschr. Vitamin-forsch.* 161 : 181-296

BACTERIAL LEAF-SPOT OF LUCERNE

By M. K. PATEL, Y. S. KULKARNI and G. W. DHANDE

(Accepted for publication Aug. 4, 1949)

THE earliest record of cultivation of lucerne (*Medicago sativa*) in India dates back to 1790. Its original habitat extended from the north-west frontier of India to Baluchistan, Afghanistan and still further to the shores of the Mediterranean. At present, it is extensively grown in Kashmir, Bihar, Bengal and Madras. In the Bombay State, it is raised as an irrigated crop round about big towns where it is prized as a green nutritious fodder for milch as well as for draft animals. During the rainy season of 1948, a bacterial leaf-spot, often mistaken for *Pseudopeziza medicaginis*, was noticed for the first time in India in a lucerne plot on the Agricultural College Farm, Poona. The pathogen was isolated and studied in detail.

Symptoms

On leaves, the disease is characterised by small, round, water-soaked spots (0.5 to 1 mm.). Some of the spots, as they grow larger (1.5 to 2 mm.) become irregular in shape having a dry pale yellow centre with brown margins, while the smaller spots remain as dark-brown specks. All such spots are surrounded by chlorotic areas. A few spots coalesce towards the tip and border of leaves resulting in local distortion of leaves (Fig. 1). Small, brown and vertical scars are often found on the stems.

Fig. 1. Bacterial leaf-spot of Lucerne showing distorted leaves

Pathogenecity

The organism was easily isolated by the usual poured-plate method and its parasitism proved on a month-old lucerne seedlings. Seedlings were kept moist by keeping them under the bell-jar before and after inoculation. Inoculations were invariably successful on lucerne, the symptoms becoming visible after an incubation period ranging from 2 to 4 days.

Morphology

The organism is a short rod measuring 1.96 x 0.80 μ, motile by a polar flagellum, gram-negative, not acid-fast, non-spore former and stains readily with common dyes.

Cultural and physiological characters

On potato dextrose agar plates, colonies are circular, smooth, shining, pulvinate with entire margins, colour baryta yellow (Ridgway) and consistency butyrous; on nutrient agar slants, growth shining, filiform, colour buff-yellow, colour of the medium not changed; in nutrient broth, good growth takes place in 24 hours. The organism liquefies gelatin and has a strong diastatic action on starch. Litmus milk is completely reduced in 8 days and casein digested; nitrates are not reduced; M. R. V. P. tests give negative results; ammonia produced; acid but no gas from arabinose, dextrose, maltose, lactose and salicin; Loeffler's blood serum not liquefied in 10 days; no growth in Uschinsky's solution; thermal death point about 51°C.

Host range :—In order to try the host range of the organism, the following hosts were inoculated; maize, wheat, jowar (*Andropogon sorghum*), bajri (*Pennisetum typhoides*), barley, oats, tomato, cotton, soya-bean, *Xanthium strumarium*, *Cassia tora*, *Ipomoea muricata* and ground-nut (*Arachis hypogaea*). In no case did the plants get infected. The organism, however, readily infects peas, *Melilotus indica* and methi (*Trigonella foenum-graecum*).

It is apparent from the above description that the symptoms, morphology, cultural and physiological characters of the organism isolated from lucerne at Poona resemble those of *Xanthomonas alfalfae* (Riker, Jones and Davis) Dowson on alfalfa (*Medicago sativa*) reported from the U. S. A., as described by Riker *et al.* (1935)*

SUMMARY

The bacterial leaf-spot of lucerne caused by *Xanthomonas alfalfae* (Riker, Jones and Davis) Dowson, was observed for the first time at Poona in India.

Three new hosts of this organism are reported.

Plant Pathological Daboratory
College of Agriculture, Poona

*Riker, A. J., F. R. Jones and C. Davis. (1935). Bacterial leaf-spot of alfalfa. *J. Agric. Res.* 51 : 177-182

BACTERIAL LEAF SPOT OF DESMODIUM DIFFUSUM DC.

By M. K. PATEL

(Received for publication Aug. 5, 1949)

IN 1939, an angular leaf spot of bacterial origin on "Patata shevra" (*Desmodium diffusum*), sometimes used for green manuring, was noticed for the first time on the Agricultural College Farm, Poona. A survey of literature indicated that Gardner and Kendrick (1923) had recorded a white organism called *Pseudomonas vignae* on *Desmodium canescens* which was later found by Clara (1933) to be a synonym of *Ps. syringae* van Hall. This paper forms a more detailed account of a short note published by Patel (1949).

The disease appears on the leaves as yellowish brown spots varying in size. When several spots are near each other, they coalesce forming large patches. A majority of the spots is angular in that they are limited by the veins and measure 1 mm. in diameter. These spots differ markedly from those caused by *Xanthomonas phaseoli* var. *sojense* Hedges (1924) on soybean leaves where they are round with an elevated centre and a clear yellow halo as stated by Uppal, Patel and Kamat (1938). The spots on *Desmodium* on the other hand, are never round and seldom show any elevated growth. Viewed from the top, infection spots are unnoticeable until at a later stage when the area becomes light to dark brown. Freshly infected spots show angular yellowing area when held against the light. Infected portion of the leaves does not generally fall out, although cracking and distortion may occur. Spots vary in number from a few to a hundred and when numerous, young leaves do not attain full size and shed easily.

Infection sometimes follows the veins and margins of the leaves. No infection has been noted on the petioles and pods. The chief distinguishing characteristic of this disease by which it can be easily separated from soybean leaf-spot, is the constant presence of water-soaked areas and the absence of pustules. These areas are limited by veins and give out very beautiful yellowish orange ooze early in the morning, especially when there is plenty of dew. Infection is mostly on the under side of the lower leaves showing that the pathogen is more active under high humidity and that it enters through the stomata. No wilting has been noticed.

ISOLATION OF THE PARASITE

The parasite can very easily be isolated from diseased tissues the by usual method using poured agar plates. Yellow, glistening, smooth, entire colonies generally begin to appear after 3 days at room temperature (25—27°C).

MORPHOLOGY OF THE ORGANISM

The organism is a short rod, either single or in pairs, never in chains and measures 1.6-2.4 x 0.4-0.8 μ, motile with a single polar flagellum, gram-negative, non-acid fast, non-capsulated, non-spore forming, yellowish, stains readily with common dyes, no involution forms.

CULTURAL AND PHYSIOLOGICAL CHARACTERS OF THE ORGANISM

Potato-dextrose agar (2 per cent.)—In plates; growth, round, viscid, smooth, wet, shining, capitate, decidedly amber yellow colonies with colourless thinner margins of 1 to 2 mm.; pulvinate; colonies do not show internal markings and measure from 5 to 18 mm. in 5 days.

Younger colonies of 2 mm. or less are lighter in colour, pulvinate, without internal markings, although in all, the central dot is present.

On slants : growth abundant, filiform, margins entire, smooth, opaque, amber yellow, odourless, butyrous, colour of the medium unchanged and growth not flowing.

Nutrient agar—On slants ; growth fair, filiform, flat, dull, smooth, opaque, pinard yellow, odourless and the colour of the medium unchanged.

Beef broth—Growth is slow in the first 24 hours with moderate clouding in 48 hours. In 4 days, good cloudy growth but there is no pellicle, sediment or change in the colour of the medium ; there is no odour.

Potato cylinders—At the end of 8 days, growth is glistening, smooth, filiform and copious, amber yellow, covering the entire surface, with practically no darkening of potato cylinders.

Synthetic media—No growth within 18 days in Cohn's, Uschinsky's or Fermi's solutions.

Plain milk—Diluted milk alone and with brom cresol purple was peptonised by the organism from 3 to 12 days. No crystals were observed even after centrifuging.

Litmus milk—The organism showed reddening in litmus milk in 10 days. Reduction of litmus is slow.

Gelatin liquefaction—Duplicate plates using Frazier's gelatin showed that the organism liquefied gelatin.

Hydrolysis of starch—The starch was hydrolysed.

Fermentation of carbon compounds—With 0.5% tannic, citric, acetic, formic acids in synthetic media the organism did not make any growth. With 1% salicin, raffinose, levulose, arabinose, xylose, dulicitol and glycerol in peptone free broths, the organism grew very poorly producing no acid and no gas. In lactose, galactose, mannitol, dextrose, matose and saccharose, the organism produces acid but no gas.

Production of indol—Indol is not produced.

Production of hydrogen sulphide—Fair amount of hydrogen sulphide is produced.

Reduction of nitrate—The organism gave cloudy growth with no gas, no precipitate and no pellicle. When tested after 3, 7 and 15 days, it gave negative test for nitrite.

Production of ammonia—The organism was grown in neutral beef broth and neutral beef broth with 1% KNO_3. Tests using Nessler's solution made on the 4th, 8th and 28th day showed no ammonia.

Inorganic nitrogen—In a synthetic medium with inorganic nitrogen as the only source of nitrogen, the organism grew fairly well.

Asparagine—In synthetic medium containing asparagine as the only source of carbon and nitrogen, the organism did not grow.

Lœffler's solidified blood serum—Growth after 4 weeks was moderate, yellowish dull with no evidence of liquefaction.

Relation to free oxygen—The organism is an ærobe.

Casein agar—Good growth with halo around the colonies measuring 1.5 cms. showing that casein had been digested.

In relation to growth—In a series of broth (peptone free) ranging from pH 3.2 to 8.5, very slight clouding occurred at pH 3.2, 5.1 while no growth was observed at 8.5. It was the heaviest at 6.8 and 7.3 while fair to moderate at 5.3 and 6.0 pH.

Relation of temperature to growth—The organism did not grow at 0°, 2°, 4 and 40°C while a slight growth occurred at 11°C, fair at 13°C, moderate at 16°, 20°, 32° and 35°C and abundant at 25 and 30°C. When after 7 days, tubes were removed and kept at 27°C, all grow abundantly except that at 40°C, showing that the organisms can withstand 0°, 2° and 4°C for 7 days without being killed while 40°C was decidedly harmful. The maximum temperature at which no perceptible growth was observed although the culture had not been killed was 38°C.

Thermal death point—About 50°C.

Crystal violet bile medium—Patel's (1926) crystal violet bile medium allows excellent growth of the organism, a fact to be utilised in its isolation from soils.

INOCULATION EXPERIMENTS

Inoculations were made by spraying bacterial suspensions on the following wounded and unwounded plants viz., *Phaseolus vulgaris* L. varieties dwarf kidney, horticultural, tender green, bountiful, and golden wax, *P. lunatus* L., *P. lunatus* var. *macrocarpus*, *P. coccineus* L., *P. mungo* L., *P. aureus* Roxb., *Vicia faba* L., *Pisum sativum* L., *Dolichos lablab* L., *Cajanus cajan* Millsp., *Vigna catjang* Walp., *V. sinensis* Endl., *Glycine max* Merr., *Lathyrus odoratus* L., *L. latifolius* L., *Alysicarpus rugosus*, *Psophocarpus tetragonolobus* DC., *Stizolobium deeringianum* Bert., *Medicago sativa* L., *Canavalia ensiformis* DC., *Crotalaria juncea* L., *Desmodium diffusum* DC., *Gossypium herbaceum* L., *Capsicum annuum* L., *Lycopersicum esculentum* Mill., *Nicotiana tabacum* L., *N. glutinosa*, *Helianthus annuus* L., *Triticum vulgare* Vill., *Avena sativa* L., *Andropogon sorghum* Brot., *Pennisetum typhoideum* Rich., *Zea mays* L., and *Oryza sativa* L., After spraying, the plants were kept for 24 hours under a bell jar in a glass-house where the temperature was kept between 80—90°F. Usually the symptoms of the disease on young leaves of *Desmodium* appeared within 7 days while none occurred on pods and stems.

The results of inoculations at 6 different times showed that the *Desmodium* pathogen is specific to its host and does not infect several other plants.

DISCUSSION AND CONCLUSIONS

It is quite clear from the data presented above that the *Desmodium* organism is morphologically and physiologically related to *X. phaseoli* and its variety *sojense* although there is distinct difference in pathological behaviour. This difference has been constant throughout the various experiments in some of which leaves had been wounded. The *Desmodium* pathogen neither produced wilting of leaves as is common with *X. phaseoli* nor did it produce pustules as is the case with *X. phaseoli* var. *sojense*. The latter organism never produces water-soaked areas as is commonly the case with the *Desmodium* pathogen. Moreover, there is no common suscept to all of them and it is therefore considered that the organism infecting *D. diffusum* should be assigned a specific rank and be called *Xanthomonas desmodii*.

TECHNICAL DESCRIPTION

Xanthomonas desmodii Uppal and Patel sp. nov.

Slender rods with rounded ends ; single or in pairs, but never in chains ; average size of single rods 1.6-2.4 x 0.4-0.8μ ; motile by single polar flagellum ; capsule absent ; no spores or involution forms ; gram-negative ; not acid fast ; aerobe ; gelatin liquefied ; ammonia not produced ; slight production of hydrogen sulphide ; nitrates not reduced ; starch hydrolysed ; casein digested ; no growth in Fermi's Uschinsky's and Cohn's solutions ; asparagine not utilised ; no indol ; blood serum not liquefied ; litmus in milk reduced ; milk peptonised ; excellent butyrous growth on potato cylinders and potato dextrose agar slants ; maximum temperature 38°C, minimum below 11°C, and optimum between 25 and 30°C ; thermal death point about 50°C ; produces acid but no gas from dextrose, galactose, lactose, mannite, maltose and sucrose when added to synthetic medium. Poor growth in salicin, raffinose, levulose, arabinose, xylose, dulcitol, glycerol and no growth in tartaric, citric, acetic and formic acids ; stains readily with common dyes. Colonies on neutral potato dextrose agar amber yellow with colourless margins, round, viscid, smooth, shining, wet, capitate with no internal markings.

Pathogenic only to *D. diffusum* producing angular, yellowish brown leaf-spots on the under side of the leaves and causing defoliation when severe. Found at Poona (India). Specimens of this disease on *D. diffusum* have been deposited in the herbaria of the Agricultural College, Poona, of the Indian Agricultural Research Institute, New Delhi and of the Commonwealth Mycological Institute, Kew, England.

SUMMARY

A bacterial leaf-spot on *D. diffusum* which in some cases causes defoliation has been found to occur at Poona, India. The symptoms on *D. diffusum* have been compared with those caused by *X. phaseoli* on *Phaseolus* sp. and *X. phaseoli* var. *sojense* on soyabean.

The causal organism has been isolated by ordinary plate methods and its pathogenicity on *D. diffusum* proved.

Except for few minor details, the organism pathogenic on *D. diffsum* resembles *X. phaseoli* and *X. phaseoli* var. *sojense* morphologically and physiologically.

Distinct differences in pathogenic behaviour between the three above mentioned organisms are noted. The *Desmodium* organism does not infect other plants although several species and varieties of legumes besides cereals and solanaceous plants have been subjected to infection.

The name *Xanthomonas desmodii* Uppal and Patel is proposed for the organism causing leaf spot and defoliation of *Desmodium diffusum*.

Plant Pathological Laboratory,

College of Agriculture, Poona

REFERENCES

Clara, F. M. (1933) ..A comparative study of the green-fluorescent bacterial plant pathogens. *Mem. Cornell Agric. Exp.* Sta. **159**

Gardner, M. W. and Kendrick J. B. (1923). Bacterial spot of lima bean. *Science* **57** : 275

Hedges, F. (1924) ..A study of bacterial pustules of soya-beans and a comparison of *Bact. phaseoli sojense* Hedges with *Bact. phaseoli* E. F. S. *J. Agric. Res.* **29**: 229-251

Patel, M. K. (1926) ..An improved method of isolating *Pseudomonas tumefaciens*. *Phytopathology* **16** : 577

(1949) ..*Xanthomonas desmodii* Uppal and Patel; sp. nov. a new bacterial leaf spot of *Desmodium diffusum* DC. *Curr. Sci.* **18** : 213

Uppal, B. N., Patel, M. K. and Kamat, M. N. (1938). Bacterial leaf spot of soybean in Bombay *J. Univ. Bom.* **6** : 16-18

Utilisation of organic nitrogen by Corynebacterium michiganensis (E. F. S.) Dowson and its possible bearing on parasitism

By V. P. BHIDE[1]

(Accepted for publication Aug. 12, 1949)

IT has been reported in a previous paper (1948) that striking differences were exhibited by eight species of wilt producing phytopathogenic bacteria in the utilisation of amino acids as sources of nitrogen for growth. In this group of organisms, comprising of two species of *Xanthomonas*, *Pseudomonas solanacearum*, *Bacterium stewartii*, and four species of *Corynebacterium*, the last named pathogens were very inactive in the utilisation of amino nitrogen.

When the above work was being carried out in the Botany Department, Iowa State College, Ames, Iowa, U. S. A., some tomato plants inoculated with different strains of *Corynebacterium michiganensis* (cause of wilt or "Grand Rapids" disease of tomatoes in North America) were available. Of the strains under test, two strains showed considerable differences in their virulence. One of these strains, CM-6, was very weakly virulent and produced only a few necrotic cankers on the plants, which never wilted. The other strain, 7433, was very virulent and produced characteristic leaf symptoms on inoculated plants, 75 per cent of which wilted in one month after inoculation. Since these two strains showed differences in virulence, a study of their nitrogen utilisation was undertaken.

Isolations were made from diseased plants and ten reisolates of CM-6 and four of 7433 were obtained and brought in pure culture. All these 14 cultures were identical in their morphological and biochemical characters ; all were Gram positive rods, yellow coloured, produced hydrogen sulphide, and coagulated milk without peptonisation. Further, all produced acid from common carbohydrates.

In order to find out whether these cultures differred in their ability to utilise organic nitrogen, they were grown on a synthetic medium to which were added organic nitrogen compound ; in one series of cultures the nitrogen compounds served as sources of nitrogen and also carbon, whilst in another series dextrose served as the source of carbon. The basal medium and the organic nitrogen compounds were the same as reported previously (1948) and the technique was essentially the same.

On media containing the organic nitrogen compounds as sources of both carbon and nitrogen, the 10 isolates of strain CM-6 did not make growth. The four isolates of strain 7433 on the other hand, grew in one week on media containing aspartic and glutamic acids. These results were confirmed on liquid media of the same composition by using the serial transfer technique of Starr and Weiss (1945).

In another series of cultures, the isolates were grown on media of the same composition as before but one per cent dextrose was added as a source of carbon. The results of this test are recorded in Table I. The results show that the reisolates of strain 7433 utilised a very large number of organic nirogen compounds as sources of nitrogen, when carbon was supplied in the form of dextrose. Of the compounds tested, only tryptophane, arginine, creatinine, choline, and para-amino-benzoic acid were not utilised by all the four isolates. On the other hand, only aspartic and glutamic acids were utilised by all the 10 isolates of strain CM-6 (the weakly virulent strain). Of the remaining compounds, only leucine was utilised by three of the ten isolates.

---

1 Present address, College of Agriculture, Dharwar

TABLE I.

Utilization of organic nitrogen with dextrose as source of carbon by isolates of Corynebacterium michiganensis

Source of nitrogen	Strain CM-6	Reisolates										Strain 7433	Reisolates			
		1	2	3	4	5	6	7	8	9	10		11	12	13	14
Glycine ..	..	—	—	—	—	—	—	—	—	—	—	—	+	—	+	+
B-alanine ..	—	+	—	—	—	—	—	—	—	—	—	—	+	+	+	+
Leucine ..	—	+	—	—	+	—	—	—	—	—	+	+	+	—	—	+
Isoleucine ..	—	—	—	—	—	—	—	—	—	—	—	+	+	+	+	+
Tyrosine ..	—	—	—	—	—	—	—	—	—	—	—	+	+	+	+	—
Tryptophane ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cystine ..	—	—	—	—	—	—	—	+	—	—	—	+	+	+	+	+
Lysine ..	—	—	—	—	—	—	—	—	—	—	—	+	+	+	+	+
Arginine ..	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—
Aspartic acid	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Glutamic acid	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Creatine ..	—	—	—	—	—	—	—	—	—	—	—	—	+	+	+	—
Creatinine ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Choline ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Paro-amino-benzoic acid	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sarcosine ..	—	—	—	—	—	—	—	—	—	—	—	—	—	+	+	+
Proteose peptone (check)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

In order to find out whether the various isolates differred in their virulence to tomato plants, inoculations were made on young tomato seedlings (var. Bonny Best). Two series of inoculations were made ; in one series seedlings about two weeks old were inoculated by pricking the leaves and stems with a flamed needle carrying a small amount of bacterial culture. Four plants were inoculated with each of the 14 isolates of the organism. Similar seedlings pricked with a flamed needle only constituted the check. The pots containing the seedlings were kept on a greenhouse bench where the mean air temperature was about 85°—90°F.

One week after inoculations were made, plants inoculated with isolates 11, 12, 13, and 14 showed typical symptoms of infection ; most of the plants showed drooping of leaves and white, cankerous areas on the stems around points of inoculation, and these extended above and below the pricked areas. In one month, 2-3 plants in each pot had wilted completely. At the same time, plants inoculated with the 10 isolates of culture CM-6 showed only a little stunting but no other symptoms.

In another series, seedlings about three weeks old were inoculated with each of the 14 isolates and also with the parent strains. Inoculations were made by cutting off tops of the seedlings with a flamed scalpel and applying inoculum to the cut ends as recommended by Ark (1944). Adequate checks consisted of plants cut in a like manner but uninoculated with the bacteria.

In four days after inoculations were made, majority of the plants inoculated with isolates 11, 12, 13, and 14 showed characteristic wilting of leaves, starting at the tips. In one month, 50 to 70 per cent of the inoculated plants in this group had wilted whereas those in the other series, viz., inoculated with isolates 1 to 10, showed only stunting but no deaths.

These results indicate a possible correlation between the virulence of *Corynebacterium michiganensis* and its ability to utilise organic nitrogen compounds, especially amino acids, as sources of nitrogen for growth. This organism is known to be extremely variable ; yellow, pink and white strains of it have been described by the Bryan (1931) and colour of the organism is shown to be associated with virulence. Ark (1646) obtained a white mutant of *C. michiganensis* by treating the white parent strain with acenapthene. The mutant was more virulent than the parent strain but was otherwise like it in morphology and biochemical reactions. In the light of the results of the present work, it would seem that the mutant might be expected to behave differently from the parent strain in respect of amino nitrogen utilization.

It is believed that this type of work would provide a new field of research in the case of phytopathogenic bacteria and may shed light on host specificity of these organisms.

REFERENCES

Ark, P. A. (1944) ..Studies and bacterial canker of tomatoes. *Phytopathology* **34** : 394-400

(1946) ..Mutation in certain phytopathogenic bacteria induced by acenapthene. *J. Bact.* **51** : 699-701

Bhide, V. P. (1948) ..A comparative study of some wilt-producing phytopathogenic bacteria. *Ind. Phytopathology* **1** : 70-92

Bryan, Mary K. (1931) ..Color variations in *Aplanobacter michiganensis*. *Phytopathology* **21** : 559

Starr, Mortimer P. and Weiss J. E. (1945) Growth of phytopathogenic bacteria in a synthetic asparagin medium. *Phytopathology* **33** : 314-318

FOUR NEW SPECIES OF FUNGI FROM BOMBAY

By B. N. UPPAL, M. K. PATEL and V. P. BHIDE

(Received for publication Aug. 15, 1949)

DURING visitss undertaken in October 1946-47, collections of fungi were made in the forest area of Mahableshwar. Among the collections were some fungi new to science. Four of these are described below :—

Phyllachora actinodaphnes Uppal, Patel and Bhide, sp. nov.

Stromata prominent, scattered, usually hypophyllous, rarely epiphyllous, small, measuring 0.5-2.00 mm. in diameter, circular in form, convex on both surfaces, dull black, surrounded by necrotic areas ; loculi numerous, closely crowded ; ostioles opening on the upper surface of the leaf ; asci clavate-cylindric, 8-spored, normally uni-seriate, a few with spores irregularly disposed ; tips of asci pointed ; bases pedicellate measuring 109-245 x 7-20 μ ; spores navicular, continuous, hyaline measuring 21-31 x 5-8 μ ; paraphyses present, but not in large numbers.

On leaves of *Actinodaphne hookeri* Meissn. at Mahableshwar, Bombay. Collected by V. P. Bhide, October 1946 (Type).

Stromata prominentia, dispersa, ut plurimum hypophylla, raro eiphylla, minuta, magnit. 0.5-2.0 mm. diam., forma circulari, convexa utraque facie, atra, circumdata regionibus necroticis ; loculi plures, adpresse aggreagati ; ostiolorum aditus in superiore facie foliorum ; asci clavato-cylindrici, octospori, ut plurimum uniseriati, nonnullorum sporis irregulariter dispositis ; ascorum apices acuti ; bases vero pedicellatae, magnit 102-245 x 21-31 μ ; spore naviculares, continuae, magnit 21-31 x 5-8 μ ; paraphyses adsunt, sed haud numerosæ.

In foliis *Actinodaphnes hookeri* Meissn. loco Mahableshwar, Bombay ; Typus lectus a V. P. Bhide, October, 1946.

P. actinodaphnes differs from *P. litseae* Koord., *P. nectandrae* St. and Dalb. and *P. ocoteicola* St. and Dalb. recorded on members of the Lauraceæ, to which family the genus *Actinodaphne* also belongs, in having larger ascospores and from *P. lapida* Syd. in having longer asci. Moreover, so far no species of *Phyllachora* has been recorded on species of *Actinodaphne*.

2. Phyllachora indica Uppal, Patel and Bhide, sp. nov.

Stromata scattered or more or less aggregate and prominent, usually epiphyllous, but sometimes hypophyllous ; also small, measuring 0.2-0.8 mm. ; oval to oblong, convex on the upper surface, dull back, surrounded by necrotic areas ; loculi few to each stroma, closely crowded ; ostioles opening on the upper surface of the leaf ; asci cylindrical, straight or slightly curved, apices rounded, constrictions at bases, paraphysate, 8-spored, uni-seriate and measure 57-83 x 5-8 μ ; spores oval, continuous, hyaline and measure 6-10 x 3-8 μ.

On leaves of *Dimeria ornithopoda* Trin. at Mahableshwar, Bombay. Collected by M. K. Patel, October 1946 (Type).

Stromata dispersa vel plus minusve aggregata ataque prominentia, ut plurimum epiphylla, aliquotiens hypophylla, minuta, magnit. 0.2-0.8 mm. ; ovate ad oblonga, convexa in superiore facie, atra, circumdata regione necrotica ; loculi haud plures

in singulis stromatibus, adpresse aggregati ; ostiolorum aditus in superiore facie folliorum ; asci cylindrici, rectivel tenuiter curvati, apices rotundati, constricti ad basim, paraphysati, octospori, uniseriati, magnit. 57-83 x 5-8 μ ; sporae ovata, continuæ, hyalinæ, magnit. 6-10 x 3-8 μ.

In foliis *Dimeriae ornithopodae* Trin. in loco Mahableshwar, Bombay. Typus lectus a M. K. Patel, October, 1946.

This fungus differs from *P. graminis* (Pers.) Fuckel, in having smaller asci and ascospores.

3. Parodiella smithiae Uppal, Patel and Bhide, sp. nov.

Perithecia superficial, globose, carbonaceous, without ostiloes, mostly on upper side of leaves, adhering by dense mat-like cushion, few to many per leaf, sometimes occupying the entire leaf area, invading epidermis and parenchymatous cells, smooth, no appendages present, measuring 108-333 μ, mostly 176-250 μ ; asci many in a perithecium, cylindrical to clavate, non-pedicellate, rounded at the apices and tapering bluntly at the base ; paraphysate, 8-spored, spores arranged in two rows of four each, hyaline, walls colourless measuring 86-133 x 18 μ, mostly 96-120 x 18 μ ; ascospores elliptic to biconvex, 2-celled (both cells equal in size), often curved, obtuse, measuring 20-37 x 6-12 μ, mostly 28-29 x 8-9 μ ; septum in the middle with a droplet in one cell.

On leaves of *Smithia bigemina* Dalz. at Mahableshwar, Bombay. Collected by M. K. Patel, October 1946 (Type).

Perithecia superficialia, globosa, carbonacea, absque ostiolis, saepissime in superiore facie foliorum adherentia pulvino denso tapeti instar, pauca ad plura in singulis foliis, aliquotiens totam folii superficiem occupentia atque epiderma cellulasque parenchymaticas invadentia, laevia, absque appendicibus, magnit. 108-333 μ, saepissime 176-250 μ ; asci plures in singulia peritheciis, cylindrici ad clavatos, non pedicellati, rotundati in apice, obtuse decrescentes ad basim, paraphysati, octospori. sporis in duas series quattuor cellularum dispositis, hyalini, parientibus incoloris. magnit. 86-133 x 18 μ, sæpissime 96-120 x 18 μ ; ascosporæ ellipticæ ad biconvexas, 2-cellulatas (utraque cellula eiusdem magnitudinis) sæpe curvatæ, obtusæ, magnit. 20-37 x 6-12 μ, sæpissime 28-29 x 8-9μ ; septum vero in medio guttula ornatum in una cellula.

In foliis *Smithiæ bigeminæ* Dalz. in loco Mahableshwar, Bombay. Typus lectus a M. K. Patel, October 1946.

The ascospores, asci and perithecia of this fungus are larger than those of species of *Parodiella* so far recorded on members of the *Leguminoseæ*.

4. Cercosporella leucadis Uppal, Patel and Bhide, sp. nov.

Spots few to numerous, epiphyllous, mummy brown (R), oblong to rectangular limited by veins, measuring 3-11 x 2 mm., yellow areas on upper surfaces of leaves corresponding with spots below ; conidiophores in fascicles of 3-20 or more, yellowish brown, non-septate, stout, with rounded or truncate apices and measure 19-26 x 4-8 μ ; conidia hyaline, straight or slightly curved, cylindrical, with rounded apices and truncate bases, pluriseptate ; septa indistinct, produced in large numbers and measuring 24-53 x 2-5 μ.

On leaves of *Leucas stelligera* Wall. (*L. hamatula*) Type and *L. ciliata* Benth. at Mahableshwar, Bombay. Collected by M. K. Patel, October 1947

Maculæ pauciores vel plures, epiphyllæ, "mummy brown" (R), oblongae ad rectangulares, foliorum nervis limitatae, magnit. 3-11 x 2 mm. luteæ regiones in superiore facie foliorum respondentes maculis in inferiore facie ; conidiophori fasciculati 3-20 vel plures, luteo-brunnei, non-septati, robusti, apice rotundato vel truncato, magnit. 19-26 x 1-8 μ ; conidia hyaline, recta vel tenuiter curvata, cylindrica, apice rotundato, basi truncata, pluriseptata, septis haud distinctis, producta numero magno, magnit. 21-53 x 2-5 μ.

In foliis *Leucadis stelligeræ* Wall. (*L. hamatulæ*) atque *L. ciliatæ* Benth., in loco Mahableshwar, Bombay. Typus lectus a M. K. Patel, October 1947.

So far, no species of *Cercosporella* has been recorded on *Leucas* or other members of *Labiateæ*.

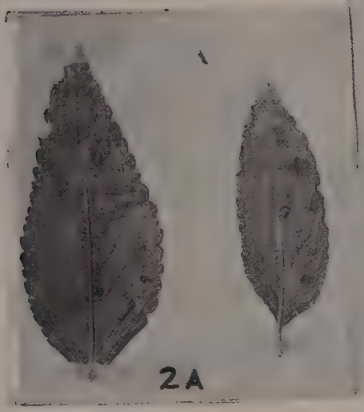
The authors wish to express their gratitude to Rev. Father H. Santapau, S.J., Head of the Department of Microbiology, St. Xavier's College, Bombay, for his kindness in rendering into latin the diagnoses of the new species and to Dr. B. B. Mundkur for his kindness in going through the manuscript of this paper.

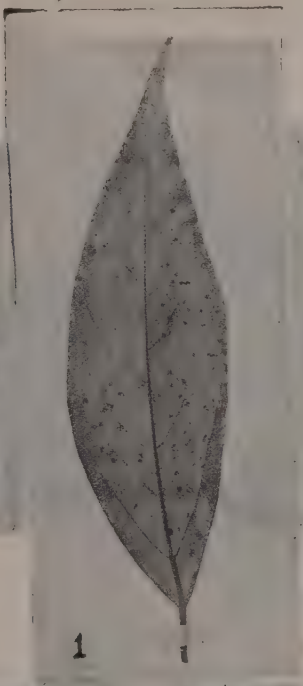
The types are deposited in the herbaria of the College of Agriculture, Poona ; of the Indian Agricultural Research Institute, New Delhi and of the Commonwealth Mycological Institute, Kew, England.

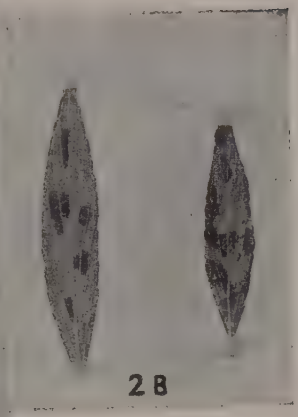
Plant Pathological Laboratory,
College of Agriculture, Poona

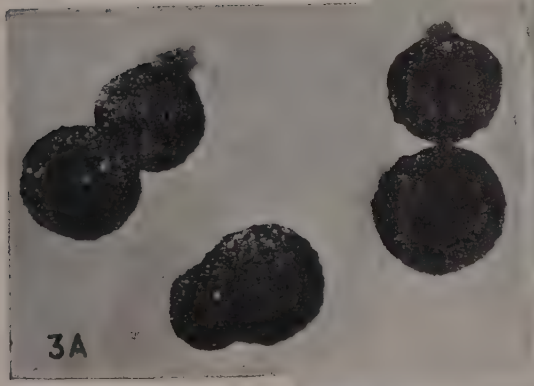
Explanation of figures

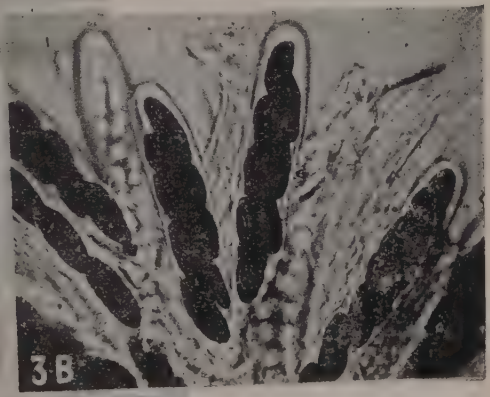
Phyllachora actinodaphnes on leaf of *Actinodaphne hookeri* showing (1) conspicuous, dark brown, round stromata on the leaf, (2a) Leaf of *Leucas stelligera* and (2b) *L. ciliata* bearing brownish fluffy growth caused by *Cercosporella leucadis*. *Parodiella smithiae* on the leaves of *Smithia bigemina* showing (3a) superficial, carbonaceous perithecia, (3b) Asci with biseriate two-celled ascospores (3c) Cross-section of a perithecium showing absence of ostiole, presence of paraphyses and the mycelium attacking the cuticle and epidermal cells.

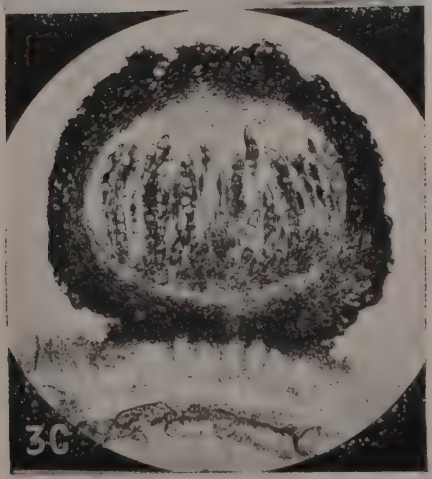

2A


1


2B


3A


3B


3C

A NEW STRAIN OF CUCUMIS VIRUS 2

By R. S. VASUDEVA, S. P. RAYCHAUDHURI and JAGANNATH SINGH

(Accepted for publication Sept. 20, 1949)

DURING 1947-48 bottle gourd [*Lagenaria leucantha* (Duch.) Rusby] plants growing in the vegetable gardens at New Delhi and in the experimental plots of the Division of Mycology were found affected by a disease which resulted in general stunting of growth and reduction in flower and fruit production. The most characteristic symptom of the disease was the occurrence of large pale yellow areas or irregular light green and dark green mottling on a limited portion or entire leaf surface. Young affected leaves exhibited wrinkled pale green surface with dark green blisters.

The transmission tests established the virus nature of the disease. The inoculations were carried out with the standard extract prepared from the diseased leaves and the experimental work was conducted with the initial inoculum multiplied in the insect-proof house. Only young actively growing plants raised in the insect-proof house were used for experimental work and for any particular experiment, plants of the same age were taken and kept under observation for a period of four weeks. Inoculations were made by dusting the leaves with finely powdered carborundum and smearing them with sterilized swab of absorbent cotton wool dipped in the standard extract. Controls similarly treated with the extract from healthy plants remained healthy.

Fig. 1. a. Healthy leaf of bottle gourd
b. Diseased leaf, affected by *cucumis* Virus, 2c.

TRANSMISSION OF THE DISEASE

The disease was successfully transmitted from diseased to healthy bottle gourd plants by means of mechanical inoculations but the period of first appearance of the symptoms varied appreciably during the winter and summer months. In winter, bottle gourd plants developed symptoms of the disease 12-18 days after inoculation. Moreover during those months hundred per cent infection was seldom obtained, while from the last week of March onwards the symptoms appeared 6-8 days after inoculation and generally all the plants inoculated got infected.

SYMPTOMATOLOGY

Symptoms on *Lagenaria leucantha* :—Bottle gourd plants developed typical symptoms as observed in the field. The first visible symptoms were irregular light green and dark green mottling of the leaf. These mottled areas enlarged and coalesced with one another and became more pronounced and gave a mosaic appearance to the leaf. Besides, a few leaves developed typical symtpom of green vein-banding. Figs. 1 and 2 show infected leaves of bottlegourd.

In some plants distortion of the leaf associated with wavy and irregular margins was seen especially during winter. Blistering and puckering were common in such leaves. The blisters looked like dark green islands between the large light green and yellow areas. The aerial parts of affected plants were stunted and seldom attained the normal size. The internodes and petioles were considerably shorter than healthy ones.

Host range of the Virus. With a view to determine the host range of the virus a number of plants belonging to different families was tested. These included *Cucurbita moschata* Duchesne, *Momordica charantia* L., *Luffa acutangula* Roxb., *Colosynthis vulgaris* Schrad., *Cucumis sativus* L., *Nicotina tabacum* L., *Nicotiana tabacum* L. var. *White Burley*, *Nicotiana glutinosa* L., *Datura stramonium* L., *Petunia hybrida* Hort., *Lycopersicum esculentum* Mill., *Hibiscus esculentus* L., *Brassica chinensis* L., *Brassica oleracea* L. var. *Golden acre*, *Brassica oleracea* L. var. *gongylodes* L., *Vigna sinensis* (L.) Savi ex Haaskr. *Cicer arietinum* L., *Cajanus cajan* (L.) Millsp. and *Pisum sativum* L.

It was observed that the virus has restricted host range and produced visible symptoms only on *Cucurbita moschata* and *Cucumis sativus* in addition to *Lagenaria leucantha*. The symptoms produced on *Cucurbita moschata* and *Cucumis sativus* are described below.

Cucurbita moschata :—The first visible symptom appears 15-18 days after inoculation when very minute green spots of the size of pin-head were produced on the leaf. These spots were slightly raised and darker in colour and scattered all over the leaf surface. No yellowing was observed at this stage but later small yellow circular spots began to appear on and along the veins. These spots increased in size and became bright yellow in 3-4 days and the veins almost appeared like yellow streaks. The affected plants were stunted in growth.

Cucumis sativus :—The first visible symptoms developed 7-10 days after inoculation on the youngest leaves in the form of small yellow spots. Later the yellow spots increased in size and the whole leaf appeared pale. The disease was always systemic and all the leaves of the affected plants exhibited the disease symptom. All growth subsequent to infection was dwarfed.

Several other plants belonging to *Cucurbitaceae*, *Solanaceae* and others stated above were incoculated and kept under observation for four weeks but none of these showed any obvious symptoms of the disease. Back inoculations on healthy bottle-gourd plants from *Datura stramonium*, *Momordica charantia*, *Luffa acutangula* and *Colosynthis vulgaris*, however, showed that the disease is carried symptomlessly in all these plants.

Fig. 2. Diseased leaf showing green vein-banding

PROPERTIES OF THE VIRUS

(i) *Dilution end-point :*—The standard extract was diluted up to required strengths with sterile distilled water and the infectivity was tested as usual on young vigorously growing bottle gourd plants. The dilution end-point of the pure sap was also determined. The results obtained show that the virus in standard extract and pure sap retains infectivity at the dilution of 1 : 1,000 and 1 : 10,000 respectively. During the course of investigations it was observed that at higher dilutions the symptoms appeared much later in comparison to lower dilutions.

(ii) *Thermal death point :*—The standard extract from young affected plants was divided into samples of 5 c.c. each in thin walled glass test tubes of uniform size and capacity. These samples were exposed to 60°, 65°, 70°, 72°, 75°, 80°, 82°,

84°, 86°, 88°, 90°, and 95°C. for ten minutes in a water bath in such a way that the portion of the tube containing the extract was completely immersed in water and the tubes were not touching the walls of the water bath. These tubes containing the sap, immediately after exposure to the required temperature were taken out and dipped in cold water. Young and healthy bottle gourd plants were inoculated with each sample thus exposed to different temperatures. Plants inoculated with unheated extract served as check. The thermal inactivation of the virus was also determined at different dilutions of the standard extract. The results are summarised in table I.

Table I

Thermal inactivation of the virus

Exposure temperature in °C.	No. of plants inoculated in each set	Standard Extract	No. of plants showing infection in different dilutions				
			1:5	1:10	1:20	1:50	1:100
Unheated check..	6	6	6	6	5	6	6
60	6	6	6	6	6	6	5
65	6	6	6	6	6	6	6
70	6	6	6	6	6	4	3
72	6	6	6	6	6	3	0
75	6	6	6	5	6	0	0
80	6	6	6	4	3	0	0
82	6	5	6	0	0	0	0
84	6	6	4	0	0	0	0
86	6	4	4	0	0	0	0
88	6	0	0	0	0	0	0
90	6	0	0	0	0	0	0
95	6	0	0	0	0	0	0

It is evident from the data that in case of standard extract the activity of the virus begins to fall at 86°C. and it is completely inactivated at 88°C. or higher.

Also that 1:5 dilution does not affect the thermal inactivation point but higher dilutions reduce it appreciably, so much so that at 1:100 dilution the virus is inactivated above 70°C.

(iii) *Longevity in vitro* :—Standard extract prepared from young diseased leaves was stored in the laboratory during May, June and July at room temperature which was in the neighbourhood of 33°—35°C. Young actively growing bottle gourd plants were inoculated with the stored juice at intervals of 1 to 90 days. In all these cases high percentage of infection was obtained.

(iv) *Filterability of the virus* :—Standard extract was filtered through filter paper impregnated with fullers' earth, and Pasteur Chamberland candles of grade L_1 and L_3. Infectivity of the filtrates was tested as usual by inoculating healthy bottle gourd plants. The results of three such experiments are set out in table II. It was observed that the infectivity of the virus is not affected during the process of filtration in all cases.

TABLE II

Filterability of the virus

Filters used	Total No. of plants inoculated	Total No. of plants infected
Unfiltered control	9	9
Filter paper (No. 42)	9	9
Fuller's earth	9	9
L_1 Chamberland candle.	6	6
L_3 Chamberland candle.	6	6

(v) *Effect of chemicals* :—The virus withstands treatment with 20 to 40 per cent alcohol while 2 percent formalin and 50 percent glycerine render it innocuous in one hour.

The virus now described lies close to Cucumber (*Cucumis sativus*) green-mottle mosaic described by Ainsworth (1935) but differs in its inability to produce visible symptoms on water-melon (*Colosynthis vulgaris=Citrullus vulgaris*), the latter acting as a symptomless carrier. Moreover, Ainsworth's cucumber green-mottle mosaic virus is not transmissible to Solanaceous hosts while the virus reported here infects *Datura stramonium* which carries it symptomlessly. The virus also differs from the mosaic of bottlegourd (*Lagenaria leucantha*) studied by Vasudeva and Lal (1943) since the latter is rendered innocuous after storage for six hours at room temperature, at a dilution of 1:500 and exposure to 60°C. for 10 minutes. Recently Capoor and Verma (1948) described a mosaic disease of bottle gourd from Bombay and designated it as *Cucumis* virus 2B, which differs from the virus described in this paper in having higher thermal death point (95°-98°C.) and dilution end point

(above one in a million) as well as in its host range. It is, therefore proposed that the mosaic virus of *Lagenaria leucantha* described herein be designated as *Cucumis* virus 2C according to classification followed by Smith (1937), and *Marmor astrictum* var. *subobscurum* var. nov. according to the classification by Holmes (1939).

SUMMARY

1. A virus disease of bottle gourd (*Lagenaria leucantha*) characterised by mosaic with blistering of leaves, green vein-banding and stunting of the plants has been described. The disease is readily sap-inoculable.

2. The disease is carried symptomlessly in *Datura stramonium, Luffa acutangula, Colosynthis vulgaris* and *Momordica charantia.*

3. The virus has thermal death point of 86°-88° C., dilution end-point of 1:1,000 and 1:10,000 in standard extract and pure sap respectively and longevity *in vitro* of more than 90 days. The virus is not inactivated by 40 percent alcohol but 2 percent formalin and 50 percent glycerine inhibit its activity. The virus passes through L_1 and L_3 Pasteur Chamberland candles and a bed of fuller's earth without any deleterious effect on its infectivity.

4. It is proposed to designate the virus described as *Cucumis* virus 2C. according to the classification by Smith (1937) and *Marmor astrictum* var. *subobscurum* var. nov. according to the classification followed by Holmes (1939).

REFERENCES

Ainsworth, G. C. (1935) ..Mosaic disease of the Cucumber. *Ann. appl. Biol.* **22** *:* 55-67

Capoor, S. P. and Varma P. M. (1948). A mosaic disease of *Lagenaria vulgaris* Ser. in the Bombay Province *Curr. Sci.* **17** *:* 274-275

Holmes, F. O. (1939) ..Hand Book of Phytopathogenic viruses. Burgess Pub. Co. Minneapolis. U.S.A. 27-29

Smith, K. M. (1937) ..A Text Book of Plant Virus Diseases. J. & A. Churchill Ltd., London, p. 83-86

Vasudeva, R. S. and Lal T. B. (1943) A mosaic disease of bottle gourd. *Indian J. agric. Sci.* **13** *:* 182-191

Division of Mycology and Plant Pathology,
Indian Agricultural Research Institute,
New Delhi

THE VALIDITY OF THE NAME PELLICULARIA KOLEROGA COOKE

By S. V. VENKATARAYAN

(Accepted for publication Nov. 28, 1949)

THE genus *Pellicularia* was established by Cooke (1875-76) for a fungus attacking coffee (*Coffea arabica* L.) in Mysore (India), the type species being *Pellicularia koleroga*. Two important characters on which he based the diagnosis, viz. the echinulate spore, and the sub-gelatinous pellicle have been shown to be incorrect by Fawcett (1914) and Burt (1918). In discussing the affinities of the fungus Cooke (1875-76) a definitely rejected the suggestion of any relationship to a Hymenomycete like *Exobasidium* or *Hymenula*, and placed it in the Hyphomycetes suggesting that it was not allied to *Zygodesmus*, but probably allied to *Amphiblistrum* Corda. He perhaps had in mind *Amphiblistrum hypochnoides* Corda which has a whitish slime (?) according to Lindau (1907). This species is considered by Saccardo (1886) to be a synonym of *Zygodesmus amphiblistrum* Sacc. on red beech bark in Reichenberg, Bohemia. The known species of *Zygodesmus* are supposed to belong to *Tomentella* or *Hypochnus*, *Pellicularia* sensu Rogers, *Peniophora* and *Coniophora* of which it is a conidial form. The diagram of *Zygodesmus fuscus* Corda and *Pellicularia koleroga* correspond very closely, as admitted by Cooke. He mistook the basidia for spores. von Höhnel (1910), examined the type specimen at Kew and, observing the basidiospores, correctly placed the fungus in the Basidiomycetes and named it *Corticium koleroga*.

Corticium being a collective genus of unrelated groups of species, Rogers (1935) segregated from it the genera *Ceratobasidium* Rogers, *Pellicularia* Cooke, and *Trechispora* Karst. He (1943) gave the name *Pellicularia* to those species of *Corticium*, *Hypochnus* and *Peniophora* which possessed areolate hymenium, short-celled stout hyphae, right-angled branching of the mycelium, stout basidia and a mucedinoid texture as in the coffee fungus which he redescribed as *Pellicularia koleroga*. As the name *Hypochnus* has been used in different senses, the name *Tomentella* Pat. (1887) has been proposed for conservation by the Nomenclature Committee of the British Mycological Society (1939) against *Hypochnus* Fr. emend. Karst. *Tomentella* is the valid name for species of resupinate Hymenomycetes with coloured, warted or aculeate spores. The spores of *Corticium* are hyaline, but according to some it includes species with a loose texture possessing hyaline and smooth or coloured and warted spores. The genus *Botryobasidium* Donk was described in 1931 for certain species of *Corticium*. Rogers admits that *Pellicularia koleroga* is a good *Botryobasidium*. But because *Pellicularia* is not a later homonym, "and Miss Wakefield's sketches of the type specimen of *Pellicularia koleroga* published by Burt show both basidia and spores," and the name "*Botryobasidium* cannot be regarded as sufficiently well established to deserve the application of the greatly overworked principle of *nomina conservanda*," he thinks that *Pellicularia* should be the valid name, and *Botryobasidium* only a synonym. *Zygodesmus fuscus* has been described recently as *Tomentella biennis* (Fr.) A. M. Rogers (Rogers, 1948). As shown by Rogers, *Zygodesmus* (1837) should supersede *Tomentella* (1887) but he says that this is not only unnecessary but impossible on the ground that it is a *nomen dubium*. *Zygodesmus fuscus* is the earliest species with a type specimen, and perhaps Saccardo (1886) was justified in adopting this as the type of the genus in view of the fact that Corda himself was responsible for this species. In this he has been followed by Clements and Shear (1931). If *Zygodesmus fuscus* can be named *Tomentella biennis* there seems to be no reason why *Pellicularia koleroga* of Cooke's conception cannot be called *Corticium koleroga* or if that is not possible, *Botryobasidium koleroga*.

Rogers has relied on Art. 18 of the International Rules of Botanical Nomenclature, (Bisby, 1945) according to which the application of names is determined by means of nomenclatural types. According to Clements and Shear (1931) "the application of the principle of priority has failed to secure uniformity and stability in botanical nomenclature, and if applied strictly to the fungi, this principle would produce a condition approaching chaos." Again, "the present use of names has been evolved by gradual changes at the hands of subsequent mycologists instead of being definitely fixed on the basis of an exact determination of the type of the original author of the name. Hence, the citation of the original author of an old name may have little to do with its present application. In fact, authors themselves have sometimes changed their descriptions, as well as the types of their genera." Rogers was probably also guided by Art. 43 by which "the name of a monotypic new genus based on a new species is validated.....by the provision of a plate with analyses showing essential characters, but this applies only to plates and generic names published before January 1, 1908." Miss Wakefield's sketches date only from 1918, the date of Burt's publication. In a pleomorphic fungus like *Pellicularia*, as per Art. 57 "the different successive states of the same species can bear only one generic and specific name (binary), that is the earliest which has been given" to the perfect form (in this case, *Corticium koleroga* or *Botryobasidium koleroga*). "Generic and specific names given to other states have only a temporary value. They cannot replace a generic name already existing and applying to one or more species, any one of which contains the 'perfect' form." In the words of Gäumann and Dodge (1928) "If one fundamentally changes the structure of this catalogue, (Fungi Imperfecti) confusion results which can be of no profit to the catalogue or its user.....Naturally it would be desirable to have the Fungi Imperfecti entirely disappear as a group, and be distributed among the natural orders of fungi. It will be generations, however, before this hope will be realized."

"To avoid disadvantageous changes in nomenclature of genera" according to priority, Art. 21 provides for the conservation of names, "by preference, those which have come into general use in the fifty years following their publication, or which have been used in monographs and important floristic works up to the year 1890." *Pellicularia* does not belong to this category. It was hardly mentioned during the years 1910 to 1943 except as a synonym. Donk, according to Bisby (1945), has proposed the conservation of *Corticium* Fr. (1835) against *Phlebia* Fr. (1821) and *Ricnophora* Pers. (1825). According to Ainsworth and Bisby (1945), conservation is also necessary of *Corticium* Pers. ex. Fr. (1836-8) against *Corticium* Pers. ex. S. F. Gray (1821) which is a synonym of *Peniophora*. Rogers (1943) says *Botryobasidium* is not sufficiently well-established to deserve conservation. He also says "the genus *Botryobasidium* Donk is a distinct and well characterized systematic and phyletic unit, for which the need had long existed." On the face of this to reduce it to synonymy and substitute it by *Pellicularia* "of which *Pellicularia koleroga* is thus far the only species" does not seem to be proper. This is against Art. 59, which says, "A name or epithet must not be rejected, changed or modified, merely because it is badly chosen, or disagreeable, or because another is preferable or better known." Under Art. 69 it is only when no legitimate name exists that a new name or epithet, or "an epithet previously given to the group in an illegitimate combination" may be adopted "if there is no obstacle to its employment in the new position or sense." There are two obstacles to the employment of the illegitimate name *Pellicularia*. One is the need to assign a proper place to the species *Pellicularia chilensis* Speg. (1910) on *Rumex crispus* mentioned by Saccardo and Trotter (1913). The stronger objection is the existence of a prior name for the perfect stage, viz., *Corticium ;* but if this is a composite genus and unsuitable for retention in its original

state, *Botryobasidium* must be deemed to be one of its segregates. Rogers himself in discussing Weber's description of *Corticium microsclerotia* [*Pellicularia filamentosa* (Pat.) Rogers] says that "the earlier description, dealing with only the imperfect stage, cannot form the basis for a basidiomycetous species". The name of an imperfect state, of which the description is merely an attribute, cannot equally apply to a perfect state. In a letter to the writer, Rogers says that Weber's description was based on material which included only the imperfect state. He obviously refers to Matz's material on which Matz (1917) based the name *Rhizoctonia microsclerotia*. Weber's (1939) material did have the perfect state, and was from the same type locality. A more serious objection pointed out by Rogers is that Weber's name is a *nomen nudum*. There is a full diagnosis in English. The note to Art. 38 (Bisby 1945) says that most mycologists accept such names, if they can read the descriptions. The latin diagnosis could be supplied even now as has been done in some cases. Cooke did not see the basidial state and gave the name *Pellicularia* to the imperfect state. This name requires to be reduced to synonymy as per Rules as Rogers (1943) partly recognized when he said the discarding of *Pellicularia* would be most appropriate. Rogers (1943) compares Cooke's accounts of the structure, and affinities of the fungus to Lloyd's "Myths of Mycology." In view of this it seems inappropriate to resurrect Cooke's name *Pellicularia*.

In the writer's view the course now open seems to be to change the name of the coffee black rot fungus to *Botryobasidium koleroga* (Cooke) comb. nov. Application of the rules would seem to justify this name on the analogy of *Tomentella biennis* (Fr.) A. M. Rogers. Failing this it appears to be necessary to take action to conserve *Pellicularia koleroga* Cooke emend. Rogers against *Corticium koleroga* (Cooke) von Höhnel and *Botryobasidium koleroga* (Cooke) comb. nov.

I am highly indebted to Dr. B. B. Mundkur, Deputy Director, Plant Diseases, Ministry of Agriculture, Government of India, for critically going through the manuscript.

SUMMARY

The implications of the revival of the name *Pellicularia koleroga* Cooke by Rogers are examined, and it is suggested that the revival is not proper. The valid name should be *Botryobasidium koleroga* (Cooke) comb. nov. In the alternative, action has to be taken to conserve *Pellicularia koleroga* Cooke emend. Rogers.

Laboratory of Plant Pathology
Department of Agriculture
in Mysore, Bangalore

LITERATURE CITED

Ainsworth G. C., and G. R. Bisby (1945) — A Dictionary of the Fungi. II ed. Imp. Mycol. Inst.

Bisby G. R. (1945) — An Introduction to the Taxonomy and Nomenclature of Fungi. Imp. Mycol. Inst.

Burt E. A. (1918) — *Corticiums* causing *Pellicularia* disease of the Coffee plant, Hypochnose of Pomaceous fruits, and *Rhizoctonia* disease. *Ann. Mo. Bot. Gdn.* **5** : 119-132

Clements F. E., and C. L. Shear (1931). The Genera of Fungi.

Cooke M. C. (1875-76) ..Some Indian Fungi. *Grevillea* **4** : 116

Cooke M. C. (1875-76a) ..Affinities of *Pellicularia*. *Grevillea* **4** : 134-135

Donk M. A. (1931) ..*Botryobasidium* Donk. *Nederl. Myc. Ver. Med.* 1820 : 116. (original not seen)

Fawcett G. L. (1914). ..*Pellicularia koleroga* on Coffee in Porto Rico. *J. Agric.. Res.* **2** : 231-233

Gäumann E. A., and Dodge C. W. (1928). Comparative Morphology of Fungi pp. 616-617 ..

von Höhnel, F. (1910) ..Fragmente zur Mykologie x. *Sitzb. K. Akad. Wiss. Wien Math-Natur Kl.* **119** : 395 (original not seen); (after Coleman L. C. et al. (1923) Black Rot or Koleroga of Coffee in Mysore. *Dep. Agric. Mys. State Mycol. Ser. Bull* **5**)

Lindau G. (1907) ..Rabenhorst's Kryptogamenflora **8** : 667

Matz J. (1917) ..A *Rhizoctonia* of the Fig. *Phytopathology* **7** : 110-117

Nomenclature Committeè of the Brit. Mycol. Soc. (1939) *Nomina generica conservanda* 1. *Trnas. Brit. Mycol. Soc.* **23** : 224-226 ..

Rogers D. P. (1935) ..*Univ. Iowa Studies Nat. Hist.* **17** : 1-43 (original not seen)

Rogers D. P. (1943) ..The Genus *Pellicularia*. *Farlowia* **1** : 95-118

Rogers D. P. (1948) ..On *Zygodesmus*. *Mycologia* **40** : 633-635

Saccardo P. A. (1886). ..*Syll. Fung.* **4** : 288

Saccardo P. A., and A. Trotter (1913). *Syll. Fung.* **22** : 1297 ..

Weber G. F. (1939). ..Web-Blight, a disease of beans caused by *Corticium microsclerotia*. *Phytopathology* **29**: 565

SOME PARASITIC FUNGI COLLECTED IN THE VICINITY OF BANARAS

By M. M. PAYAK

(Accepted for publication Dec. 20, 1949)

BANARAS is situated in the middle of the Gangetic plain and for the most part represents an intensively cultivated region. The topography of the place is fairly even. The flora includes not only cultivated plants, but also herbs, shrubs and trees which are either wild or escapes of the cultivated plants. By studying the parasitic fungi of the plants near Banaras, one can gather some idea of the parasitic mycoflora prevailing in other parts of the Gangetic plain. Mitter and Tandon (1930 and 1937) published an account of the fungus flora of Allahabad, which is an area similar to Banaras. Most of the specimens described in this paper were collected in the vicinity of the city of Banaras. The specimens are deposited in the Department of Plant Pathology, College of Agriculture, Banaras Hindu University.

PHYCOMYCETES

1. **Choanephora infundibulifera** (Currey) Cunningham on faded flowers of *Hibiscus esculentus* L. 11. 11. 1948, Leg. M. M. Payak
2. **Cystopus bliti** (Biv.) de Bary on leaves of *Digera arvensis* Forsk. 2. 9. 1947, Leg. Ramchandra
3. **Cystopus candidus** (Pers.) Lév. on *Brassica campestris* L. 2. 3. 1949 Leg. M. S. Pavgi
4. **Cystopus ipomœæ-panduratæ** (Schw.) Stev. & Swingle on leaves of *Ipomœa Sp.* 13. 8. 1948 Leg. M. M. Payak
5. **Cystopus platensis** Speg. on *Bœrhaavia diffusa* 12. 11. 1949 Leg. M. J. Thirumalachar
6. **Peronospora brassicæ** Gäuman on leaves of *Raphanus sativus* L. 7. 1. 1949 Leg. M. M. Payak
7. **Peronospora gaumanni** Mundkur on leaves of *Argemone mexicana* L. 14. 2. 1949 Leg M. M. Payak
8. **Peronospora viciæ** (Berk.) de Bary on leaves of *Pisum sativum* L. 10. 1. 1949 Leg. M. M Payak
9. **Phytophthora colocasiæ** Racib. on leaves of *Colocasia antiquorum* Schott. 12. 9. 1948 Leg. M. M. Payak
10. **Phytophthora parasitica** Dastur on leaves of *Ricinus communis* L. 14. 3. 1948 Leg. M. M. Payak
11. **Pseudoperonospora cubensis** Rost. on leaves of *Luffa acutangula* Roxb. 12. 11. 1948 Leg. M. M. Payak
12. **Pythium aphanidermatum** (Edson) Fitzp. on fruits of *Lageneria vulgaris* Ser. 12. 8. 1948 Leg. M. M. Payak
13. **Rhizopus artocarpi** Racib. on fruits of *Artocarpus integrifolia* L. 20. 12. 1948 Leg. M. M. Payak
14. **Sclerospora graminicola** (Sacc.) Schroet. on leaves and inflorescence of *Pennisetum typhoides*. Stapf & Hubbard. 10. 10. 1948 Leg. M. M. Payak

ASCOMYCETES

15. **Asterina lawsoniæ** P. Henn. & Nyman on leaves of *Lawsonia inermis* L. 11. 1. 1949 Leg. M. M. Payak
16. **Erysiphe cichoracearum** DC. (oidium stage only) on leaves of *Cucumis melo* L. 12. 2. 1949 Leg. M. M. Payak
17. **Erysiphe polygoni** DC. (oidium stage only) on leaves of *Pisum sativum* L. 17. 2. 1949 Leg. M. M. Payak
18. **Phyllachora cynodontis** (Sacc.) Niessl. on leaves of *Cynodon dactylon* Pers. 10. 2. 1949 Leg. M. M. Payak
19. **Taphrina maculans** Butler on leaves of *Curcuma longa* L. 8. 12. 1948 Leg. M. M. Payak

BASIDIOMYCETES

(Ustilaginales)

20 **Cintractia minor** (Clinton) Jackson on peduncles and spikelets of *Cyperus pangorei* Rottb. 3. 10. 1948 Leg. M. M. Payak
21 **Entyloma oryzæ** Sydow on leaves of *Oryza sativa* L. 1. 11. 1949 Leg. M. S. Pavgi & M. J. Thirumalachar
22 **Neovossia horrida** (Tak.) Padwick & Azmat. on *Oryza sativa* L. 14. 11. 1949 Leg. M. S. Pavgi & Thirumalachar
23 **Sphacelotheca erythreænsis** (Syd.) Clinton on *Manisuris granularis* L. 10. 10. 1948 Leg. M. S. Pavgi
24 **Sphacelotheca sorghi** (Link) Clinton in the ovaries of *Andropogon halepensis* Brot. 18. 10. 1948 Leg. M. M. Payak
25 **Tilletia narayanaraona** Mundk. & Thirumalachar on *Panicum trypheron* Schultz 10. 11. 1949 Leg. M. M. Payak & M. J. Thirumalachar
26 **Tolyposporium penicillare** Bref. on *Pennisetum typhoides* 12. 10. 1948 Leg. M. M. Payak
27 **Ustilago avenæ** (Pers.) Rost. on *Avena sativa* L. 10. 4. 1948 Leg. M. M. Payak
28 **Ustilago cynodontis** P. Henn. on *Cynodon dactylon* Pers. 7. 10. 1948 Leg. M. M. Payak
29 **Ustilago hordei** (Pers.) Lagerh. on *Hordeum cvulgare* L. 10. 2. 1949 Leg. M. M. Payak
30 **Ustilago kolleri** Wille on *Avena sativa* L. 10. 4. 1948 Leg. M. M. Payak
31 **Ustilago nuda** (Jensen) Rostr. on *Hordeum vulgare* L. 10. 2. 1949 Leg. M. M. Payak
32 **Ustilago panici-glauci ?** (Wallr.) Wint. on *Setaria glauca* Beauv. 5. 9. 1948 Leg. M. M. Payak
33 **Ustilago scitaminea** Syd. var. **sacchari-barberi** Mundkur on *Saccharum officinarum* L. 10. 4. 1948 Leg. M. M. Payak
34 **Ustilago spermophora** Berk & Curt. on *Eragrostis sp.* 15. 11. 1948 Leg. M. M. Payak
35 **Ustilago tritici** (Pers.) Rostr. on *Triticum vulgare* Vill. 2. 3. 1949. Leg. M. M. Payak

(Uredinales)

36 **Cerotelium fici** (Cast.) Arth. on leaves of *Ficus carica* 24. 11. 1949. Leg. M. J. Thirumalachar
37 **Melampsora lini** (Pers.) Lév. on leaves and stems of *Linum usitatissiumum* L. 13. 3. 1949 leg. K. C. Mahanta
38 **Puccinia butleri** Syd. on all parts of *Launea asplenifolia* Hooker 10. 2. 1949 Leg. M. M. Payak
39 **Puccinia glumarum** (Schm.) Erikss. & Henn. on leaves of *Hordeum vulgare* L. 25. 2. 1949 Leg. M. M. Payak
40 **Puccinia graminis** Pers. var. *tritici* Erikss. on culms of *Triticum vulgare* Vill. 7. 3. 1949 Leg. Payak
41 **Puccinia penniseti** Zimmer. on leaves of *Pennisetum typhoides* 6. 11. 1949 Leg. M. J. Thirumalachar
42 **Puccinia triticina** Erikss. on leaves of *Triticum vulgare* Vill. 7. 3. 1949 Leg. M. M. Payak
43 **Scopella echinulata** (Niessl.) Mains on leaves of *Bassia latifolia* Roxb. 10. 11. 1949 Leg. Thirumalachar
44 **Uromyces ciceris-arientini** (Grogn.) Jacs. & Boyer on leaves of *Cicer arientinum* L. 25. 2. 1949 Leg. K. C. Mahanta.
45 **Uromyces decoratus** Syd. on leaves of *Crotalaria .juncea* L. 4. 12. 1949 Leg. M. J. Thirumalachar
46 **Uromyces fabæ** (Pers.) de Bary on leaves of *Pisum sativum* L. 24. 2. 1949 Leg. M. M. Payak.
47 **Uromyces hobsoni** Vize. on *Jasminum grandiflorum* L. 24. 9. 1949 Leg. M. J. Thirumalachar.

FUNGI IMPERFECTI

48 **Alternaria brassicæ** (Berk.) Sacc. on leaves of *Brassica oleracea* L. 18. 12. 1949 Leg. M. M. Payak
49 **Alternaria solani** (Ell. & Mart.) Jones & Grout on leaves of *Solanum tuberosum* L. 12. 1. 1948 Leg. M. M. Payak
50 **Aschersonia raciborskii** Zimmer. on *Aleyrodes* infesting the leaves of *Citrus aurantifolia* Swingle 30. 11. 1949. Leg. M. M. Payak
51 **Cercoseptoria balsaminæ** Syd. on *Impatiens balsamina* L. 9. 8. 1948. Leg. M. M. Payak
52 **Cercospora barlericola** Payak & Thirumalachar sp. nov.

Infection spots irregular to angular, 2-5 mm. in diameter, at first dark reddish-brown, later becoming pale-brown or dingy grey in the centre. Fruiting bodies amphigenous; stromata subglobose, brown, 17-30 μ in dimeter. Condiophores pale olive-brown, 2-4 septate, geniculate,

unbranched, measuring 52-90 X 4-6 μ. Conidia hyaline, clavate-cylindric, 3-9 septate, base long obconically truncate, tip acute, 36-132 X 2-4 μ.

Hab. on leaves of *Barleria cristata* Linn. Banaras Hindu University 9. 12. 1949 (Payak) type.

Maculae infectionis irregulares usque angulares, 2-5 mm. in diameter; primum atrobadiae, demum centro pallide brunneo usque sordide griseo. Fructificatio amphigena; stromata subglobosa, brunnea 17-30 μ in diam. Conidiophora pallide olivaceo-brunnea, 2-4 septata, geniculata, non-ramosa, 52-90 x 4-6 μ. Conidia hyalina, cylindro-clavata, 3-9 septata, basi obconice truncata, apice acuto, 36-132 x 2-4 μ.

Barleria cristata is an ornamental shrub grown in the gardens. The fungus incites severe leaf spotting and causes premature defoliation of the shoots.

53 **Cercospora blumeæ** Thuem. on leaves of *Blumea sp.* 8. 1. 1949. Leg. M. M. Payak
54 **Cercospora carthami** Sunder. & Ramakr. on leaves of *Carthamus tinctorius* L. 2. 2. 1949 Leg. M. M. Payak
55 **Cercospora ricinella** Sacc. & Berl. on leaves of *Ricinus communis* L. 12. 12. 1948 Leg. M. M. Payak
56 **Colletotrichum falcatum** Went. on leaf-sheaths and culves of *Saccharum officinarum* L. 22. 12. 1948 Leg. M. M. Payak
57 **Colletotrichum graminicolum** (Ces.) Wilson on leaves of *Andropogon sorghum* Brot. 20. 9. 1948 Leg. M. M. Payak
58 **Helminthosporium oryzæ** Breda de Haan on leaves of *Oryza sativa* L. 17. 9. 1948 Leg. M. M. Payak
59 **Helminthosporium sativum** Pammel, King & Bakke on *Hordeum vulgare* L. 15. 2. 1949 Leg. M. M. Payak
60 **Pleospora cassiæ** Thirumalachar & Narasimhan on leaves of *Cassia fistula* L. 15. 11. 1948 Leg. M. M. Payak
61 **Phomopsis artocarpi** Syd. on leaves of *Artocarpus integrifolia* L. 15. 11. 1948 Leg. M. M. Payak
62 **Phyllostictina tinosporæ** Syd. on dry dead leaves of *Tinospora tomentosa*. (Sydow (1932). has described this species on *Tinospora cordifolia* collected by Ajrekar from Ahmedabad.) 15. 12. 1948 Leg. M. M. Payak
63 **Piricularia oryzae** Cav. on *Oryza sativa* L. 12. 11. 1949 Leg. M. J. Thirumalachar
64 **Septoria arcuata** Cke. on leaves of *Ficus bengalensis*. L. 17. 9. 1948 Leg. M. M. Payak

The author wishes to acknowledge his indebtedness to Dr. M. J. Thirumalachar for his kind help and guidance in the preparation of the manuscript and identification of certin specimens.

Department of Plant Pathology,
College of Agriculture,
Banaras Hindu University

REFERENCES

Mitter, J. H. and Tandon, R. N. (1930) ..The fungus flora of Allahabad II. *J. Indian Bot. Soc.* 9 : 190-198

———————————(1937) ..Fungi of Allahabad, India. Part III *Proe. Indian Acad Sci.* **6** : 194-201

Sydow, H. (1932) ..Novae Fungorum Species. *Ann. Mycol., Berl.*,30 : 111

GENERA OF RUSTS II

By M. J. THIRUMALACHAR and B. B. MUNDKUR

(Accepted for publication Dec. 31, 1949)

41 **DESMELLA** Sydow in *Ann. mycol. Berl.* **16,** p. 241. 1918 Fig. 36

Syn. *Edythea* Jackson, *Mycologia,* **23 :** 97, 1931

PYCNIA and aecia unknown. Uredia minute, superstomal, with sporogenous stalks emerging through the stomata and bearing at their apices several pedicellate spores ; urediospores echinulate. Telia resembling uredia, superstomal ; teliospores pedicellate, 2-celled, pale yellowish or hyaline ; germinating at maturity.

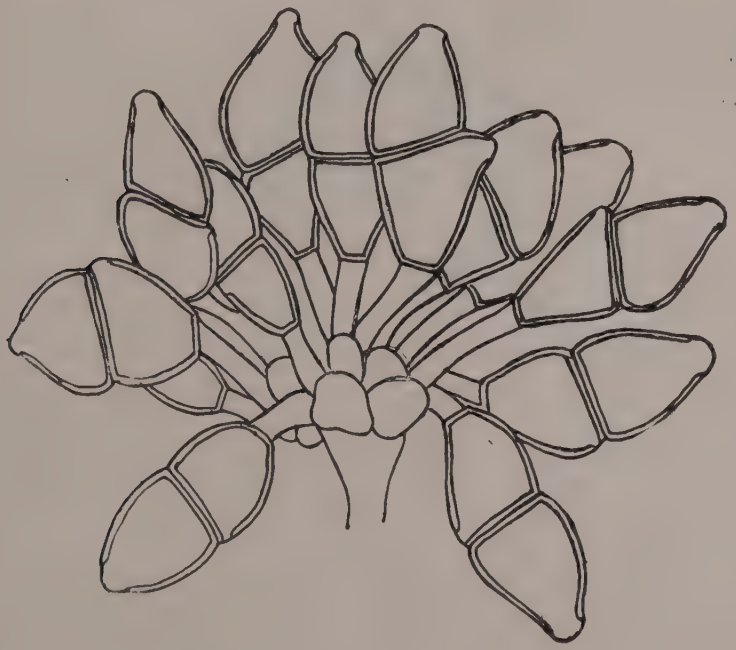


Fig. 36. Desmella

TYPE SPECIES : *Desmella aneimiae* Sydow on *Aneimia* sp. (Schizaeaceae)

DISTRIBUTION : South America (8 species)

NOTES : The structure of the sori in *Desmella* resembles that of *Hemileia.* In both, the sori consist of tufts of hyphae emerging through the stomata and bearing spores above the epidermis. An account of the morphology of the sori of *Desmella aneimiae* and *Desmella superficialis* was published by Cummins (1940). Teliospores are 2-celled and hyaline and the septa are either transverse or vertical, when they appear diorchioid. Jackson (1931) established the genus *Edythea* to accomodate three rusts on *Berberis.* They had superstomal uredia and telia with nearly colour-

less, mostly diorchioid teliospores that germinated immediately. Thirumalachar and Cummins (1948) have shown that there is little difference in the characters of *Desmella* and *Edythea* and merged the latter into the synonymy of the former. Arthur (1915) doubted if these forms on ferns, now placed in *Desmella*, could be included in the Uredinales. There is no doubt however that *Desmella* is a member of the Pucciniaceae (Dietel, 1928).

Arthur, J. C. (1915). *Mycologia* **7** : 325-326
Arthur, J. C. (1927). *North Amer. Fl.* **7** : 806
Cummins, G. B. (1940). *Ann. mycol. Berl.* **38** : 335-338
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 51
Jackson, H. S. (1931). *Mycologia* **23** : 96-116
Thirumalachar, M. J., and Cummins, G. B. (1948) *Mycologia* **40** : 417-422

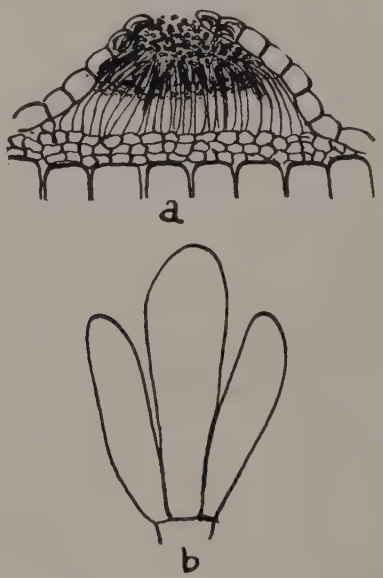


Fig. 37. Desmotelium. a. Pycnia. b. Teliospores

42 **DESMOTELIUM** Sydow in *Ann. mycol. Berl* **35,** p. 252, 1937 Fig. 37

Pycnia subepidermal, conoid, without conspicuous ostiolar paraphyses. Aecia uredinoid, subepidermal, with broad pulvinate hymenium, bordered by incurved paraphyses ; aeciospores bluntly triangular, echinulate, verrucose, coloured and resembling urediospores. Uredia subepidermal, erumpent, with broad hymenium and surrounded by marginal, incurved paraphyses ; urediospores globóse to ellipsoid, echinulate and coloured. Teliospores arising within the uredia, ovate to oblong to subfusoid, hyaline, sessile, developed in clusters on sporogenous basal cells ; germinating at maturity by prolongation of the spore apex into a 4-celled external promycelium.

TYPE SPECIES : *Desmotelium coaetaneum* Sydow on *Millettia rhodantha* (Leguminosae)

DISTRIBUTION : Sierra Leone (one species)

NOTES : In describing this genus, Sydow stated that aecia (primary uredia)' uredia and telia are subcuticular but Mains (1940) found that the sori of all the spore forms are subepidermal. Pycnia are conoid, aecia and uredia are naked and bordered by paraphyses. Teliospores germinate immediately by the prolongation of the spore apex. The clustered nature of the teliospores on sporogenous basal cells indicates one of the modes of teliospore development. Some of the characters, such as subepidermal pycnia, sessile, hyaline and clavate teliospores germinating without a rest period, are similar to those of *Chrysocelis* Lagerheim, with which the genus may prove cogeneric. In *Chrysocelis lupini*, the aecia are without peridia and open out by a central pore and uredia are unknown so far. Due to our limited knowledge about the life cycle of *Chrysocelis*, it seems advisable to retain *Desmotelium* tentatively.

Mains, E. B. (1940) *Bull. Torrey bot. Cl.* **67** : 707
Thirumalachar, M. J. and Cummins, G. B. *Mycologia* (in press)

Fig. 38. Diabole

43 **DIABOLE** Arthur in *Bull. Torrey bot. Cl.* **49** : p. 194, 1922 Fig. 38

Pycnia, aecia and uredia unknown. Telia subcuticular, erumpent and pulverulent ; teliospores occurring in pairs on apical cells of the pedicel, often 2 or 3 pairs of spores on apical cells borne on a common pedicel, deep reddish-brown, warty at the apical half and of a lighter shade and smooth at base ; pedicel hyaline, deciduous.

TYPE SPECIES : *Diabole cubense* Arthur on *Mimosa pigra* (Leguminosae)

DISTRIBUTION : Cuba (one species)

NOTES : Cummins (1935) has pointed out the relationship between *Diabole* and *Dicheirinia*. In the presence of the apical cell on the pedicel of teliospores the two genera resemble each other. In *Diabole* each pedicel bears several pairs of teliospores, each pair being borne on a single apical cell. The spores are independent of each other in *Diabole ;* whereas in *Dicheirinia* they are laterally united. Cummins further found evidence for the occurrence of two subequatorial germ pores in *Diabole* in contrast to a single germ pore at the apex in *Dicheirinia*. Further the sori are subcuticular in the former and subepidermal in the latter. These differences are marked enough and indicate that the two genera are not so closely related as one is led to conclude from the discussion given by Dietel (1926) about their relationships.

Arthur, J. C. (1925) North Amer. Fl. **7** : 719
Cummins, G. B. (1935) *Mycologia* **27** : 151-159
Dietel, P. (1926). *Ann. mycol. Berl.***24** : 130-131
Dietel, P. (1928) Die natürlichen Pflanzenfamilien **6** : 67

Fig. 39. Dicheirinia

44 **DICHEIRINIA** Arthur in *North Amer. Fl.* **7**, p. 147, 1907 Fig. 39

Pycnia subcuticular, conoid, crescentic, without conspicuous ostiolar paraphyses. Aecia subepidermal, uredinoid, without peridium, paraphysate ; aeciospores resembling urediospores. Uredia when present, subepidermal, paraphysate ; urediospores borne singly on pedicels, walls coloured, echinulate with distinct germ pores. Telia subepidermal, with few to many paraphyses ; teliospores two or three, laterally united and borne on a common pedicel ; walls coloured and coarsely tuberculate or digitate, with an apical germ pore in each cell ; pedicels with 1-3 apical cells.

TYPE SPECIES. *Dicheirinia binata* (Berk. & Curt.) Arthur on an unknown host (Erythrina ?)

DISTRIBUTION: Central and South America (7 species)

NOTES: The occurrence of two to three celled teliospores laterally united and borne on a single pedicel is also characteristic of *Hapalophragmium* and *Diorchidium*. But the presence of apical cells in the pedicel clearly differentiates *Dicheirinia*. The sculpturings of the teliospores while offering a means of separating different species show a marked similarity in being coarsely cubical or digitate and numer-

ous at the apex of the spore. As already stated *Trachyspora* shows similar type of sculpturing, and apical cell in the pedicel but is 1-celled (Mundkur and Thirumalachar 1946). Cummins (1935) discusses relationship between *Dicheirinia* and *Diabole*.

Cummins, G. B. (1935). *Mycologia* **27**: 151-159

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 67

Jackson, H. S. (1931). *Mycologia* **23**: 332-364

Mundkur, B. B. and Thirumalachar, M. J. (1946) *Mycol. Pap. Commonwealth Mycol. Inst.* No. 16, p. 13

Sydow, H. & P. (1915). Monogr. Ured. III: p. 201

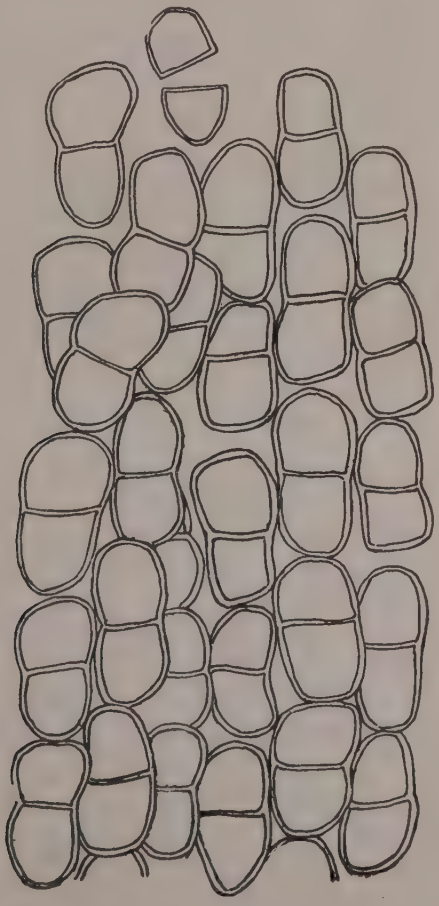


Fig. 40. Didymopsora

45 **DIDYMOPSORA** Dietel in *Hedwigia* **38,** p. 254, 1899, Fig. 40

Pycnia subepidermal, applanate. Aecia unknown. Uredia subepidermal, erumpent, pulverulent. Telia subepidermal, without peridia ; teliospores 2-celled, sessile, hyaline or slightly coloured, developed in succession from the basal hymenium and producing short ephemeral spore-chains ; germinating at maturity forming a 4-celled external promycelium.

TYPE SPECIES : *Didymopsora solani-argentei* (P. Henn.) Dietel on *Solanum argenteum* (lectotype selected by Arthur)

DISTRIBUTION : South America, India (6 species)

NOTES : The genus has been recorded on Solanaceae, Compositae, Teliaceae and Rutaceae. The two-celled, sessile teliospores in chains which form short ephemeral columns and germinate immediately without a rest period, are important characters of the genus. It is distinguished from *Pucciniosira* in not possessing the characteristic peridial cells. The two cells of the teliospores in *Didymopsora solani-argentei*, *Didymopsora solani* and *Didymopsora chuquiraguae* are fragile and easily get separated. Only pycnia and telia were described by Dietel which gave an indication that the genus is a microcyclic rust. However uredia were seen in *Didymopsora toddaliae* and *Didymopsora macrospora* recorded by Thirumalachar in India (1942) on *Toddalia* spp. The pycnia in these two species were intra-epidermal in contrast to the subepidermal pycnia in the type. The urediospores of *Didymopsora toddaliae* have seriate lateral ridges like those of *Skierka*. The rust was first named *Uredo toddaliae* by Petch and later transferred to *Ctenoderma* by Sydow (1919). In the type and authentic specimens in three out of four species of *Ctenoderma*, Mains (1939) was able to see the telial stage and he transferred them to *Skierka*. Sydow had evidently mistaken the urediospores for teliospores and though the urediospores bore a good resemblance to those of *Skierka*, Mains deferred transferring

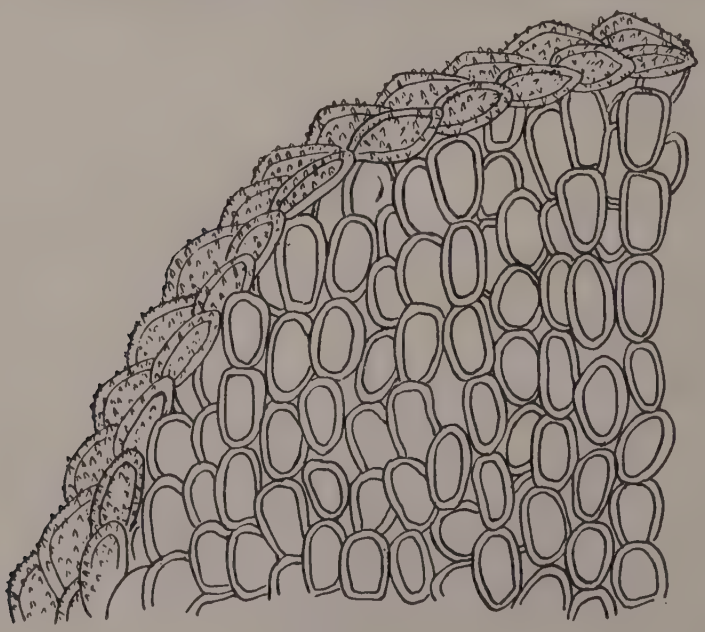


Fig. 41. Dietelia

it to that genus and retained it under *Ctenoderma*. The disocvery of telia by Thirumalachar indicated that it is a species of *Didymopsora*. Consequently the genus *Ctenoderma* Sydow is without any species and is invalidated.

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 94
Mains, E. B. (1939). *Mycologia* **31** : 179-189
Sydow, H. & P. (1915). Monogr. Ured. III : 554-556
Sydow, H. (1919). *Ann. mycol. Berl.* 17 : 103
Thirumalachar, M. J. (1942). *Proc. Indian Acad. Sci.* **16** : 165-174

46 **DIETELIA** P. Hennings in *Hedwigia*, **37**, p. 215, 1899, Fig. 41

Pycnia, aecia and uredia unknown. Telia subepidermal, erumpent, small, sunk in the host, peridiate ; teliospores one-celled, developing in chains, ovate, ellipsoid, with brownish-yellow membrane.

TYPE SPECIES : *Dietelia verruciformis* P. Henn. on *Sida macrodon* var. *intermedia* (Malvacae)

DISTRIBUTION : Argentina (one species)

NOTES : The occurrence of teliospores in chains in sori bordered by peridia is an important diagnostic character which differentiates the genus from *Baeodromus*. Coloured teliospores dintinguish it from *Endophyllum*.

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 96
Sydow, H. & P. (1915). Monogr. Ured. III : 523-526

47 **DIORCHIDIUM** Kalchbrenner in *Grevillea* **11**, p. 26, 1882, Fig. 42

Pycnia and aecia unknown. Uredia and telia as in *Puccinia ;* teliospores 2- celled with a longitudinal wall, intensively brown with a laterally situated germ pore in each cell ; pedicellate.

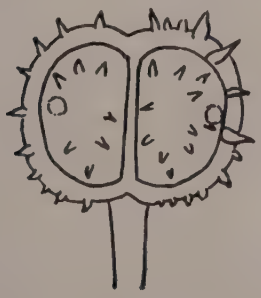


Fig. 42. Diorchidium

TYPE SPECIES : *Diorchidium woodii* Kalchbr. & Cooke on *Milletia caffra* (Leguminosae)

DISTRIBUTION : Wide (11 species)

NOTES : *Diorchidium* differs from *Dicheirinia* in having no apical cells on the pedicel and in most species having a lateral rather than an apical disposition of the germ pores.

It is a matter of debate whether this genus should be retained as distinct from *Puccinia* since there is a tendency towards an oblique to almost longitudinal septation in the spore in *Puccinia* species. These integrating variations from transverse to vertical septation are often seen in the same species in some *Puccinia*. For the present the genus is retained for those species in which a large majority of teliospores show vertical septation.

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 68
Doidge, E. M. (1926). *Bothalia* **2** : 137
Sydow, H. & P. (1904). Monogr. Ured. I : 836

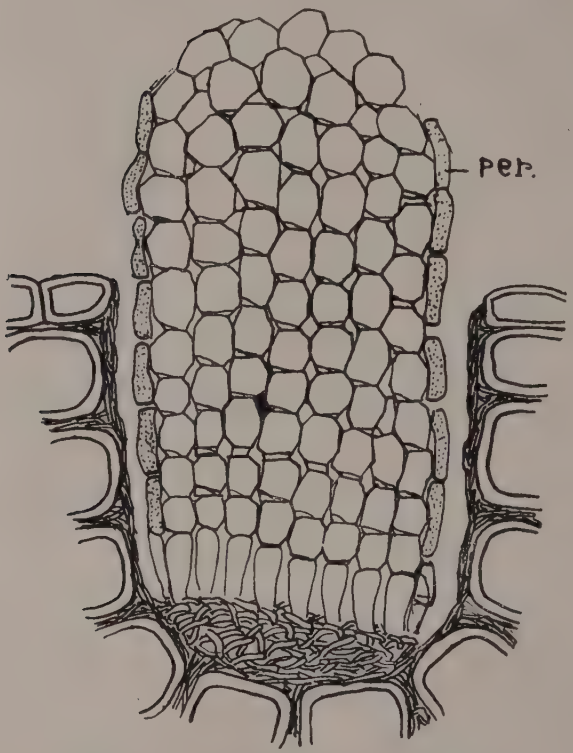


Fig. 43. Endophylloides. Per. Peridium

48 **ENDOPHYLLOIDES** Whetzel and Olive in *Amer. J. Bot.* **4**, p. 50, 1917, *emend* Fig. 43

Pycnia, aecia and uredia unknown. Telia subepidermal, aecidioid, erumpent and peridiate ; teliospores developed in chains with distinct, sterile, intercalary cells, one-celled, angularly globoid to polygonal ; spore chains adhering laterally with one another to form compact columns within the sorus and slightly protruding above the host ; spores produced in the sorus in basipetal succession ; mature spores germinating away at the apex.

TYPE SPECIES : *Endophylloides portoricensis* Whetzel and Olive on *Mikania cordifolia* (Compositae)

DISTRIBUTION : Peurto Rico, Trinidad, Guatemala (One species)

NOTES : In establishing the genus Whetzel and Olive stated that the peridium was wanting or at least inconspicuous. A detailed examination by Thirumalachar (1950) however has shown that the sori are peridiate. The peridium is composed of cylindric cells which line the sorus in early stages and later as the spore column is organised, forms a delicate layer attached to the column. Usually in mature sori, the spore columns are separated off from the margin of the sorus by a space so that the peridial cells do not abut on the sides of the sorus but are carried over on the spore column as in *Gambleola* (Thirumalachar, 1947).

Endophylloides differs from *Endophyllum* in the spore chains being not pulverulent at the apex and separating away but remain more permanently united in the form of short protruding columns. It can be separated from *Dietelia* by the lack of thick-walled yellowish brown teliospores of the latter. There is some superficial resemblance with *Cerotelium* which also forms small columnar telia of one-celled teliospores but the presence of sterile intercalary cells and the non-pulverulent nature of the telial column in *Endophylloides* is a distinctive feature.

Arthur, J. N. North. Amer. Fl. **7**: 699

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 93

Thirumalachar, M. J. (1947). *Mycologia* **39**: 231-248

Thirumalachar (1950((in press)

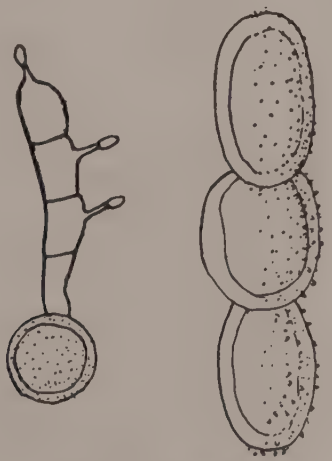


Fig. 44. Endophyllum

49 **ENDOPHYLLUM** Léveillé in *Mem. Soc. Linn. Paris* 4, p. 208, 1825 Fig. 44

Pycnia subepidermal, deeply seated, with ostiolar paraphyses. Aecia and Uredia unknown. Telia subepidermal, aecioid, usually with well developed peridium, erumpent, pulverulent; teliospores catenulate, easily separable, one-celled, ovate-ellipsoid or polygonal, yellow, separated by intercalary cells in some cases; germinating by a 4-celled external promycelium bearing globular sporidia.

TYPE SPECIES: *Endophyllum persoonii* Lév. on *Sempervivum tectorum* (Crassulaceae)

DISTRIBUTION: Wide spread (20 species)

NOTES: The essential features of the sorus of *Endophyllum* are the same as in *Aecidium* except that the spores have assumed the function of teliospores. Jackson (1931) in a critical account of the evolutionary tendencies in the Uredinales puts forth the view that all the known forms of *Endophyllum* show close correlation with the aecial forms of heteroecious species as to host, habit and morphology. He thinks that *Endophyllum* forms present reduced forms derived from the haploid generation of heteroecious species of *Puccinia, Uromyces* and possibly other genera.

Cytological studies of *Endophyllum* spp. have shown a range of variation in the nuclear cycle. Several species develop two sporidia on a 2-celled promycelium. In *Endophyllum valerinae-tuberosae* the promycelium is 2-celled but there is a single sporidium. The occurrence of a single sporidium is reminiscent of *Monosporidium* discussed under *Aecidium*. Cytological study of *Monosporidium* would undoubtedly clarify whether it is synonymous with *Aecidium* or *Endophyllum*.

Arthur, J. C. (1907). North Amer. Fl. **7**: 126
Dietel, P. (1928). Die natülichen Pflanzenfamilien **6**: 92
Jackson, H. S. (1931). *Mem. Torrey bot. Cl.* **18**: 1-108
Sydow, H. & P. (1915). Monogr. Ured. III : 527-537

Fig. 45.
Eriosporangium

50 **ERIOSPORANGIUM** Bertero in *Ann. Sci. Nat. 3*, V, p. 269, 1846 Fig. 45

Syn. *Argomyces* Arthur, North Amer. Fl. **7**: 217, 1912
Argotelium Arthur, *Res. Sci. Congr. Bot. Vienne*, p. 343, 1906
Polioma Arthur, *J. Mycol.* **13**: 29, 1907
Poliomella Sydow, *Ann. mycol.* Berl. **20**: 122, 1922

Pycnia subepidermal, flask-shaped, sunk in the host. Aecia sub-epidermal, erumpent, caemoid without peridium or with loose and fragile peridium. Uredia sub-epidermal, erumpent, without paraphyses. Telia sub-epidermal ; teliospores 2-celled, with hyaline or coloured membrane and indistinct germ pores ; germinating immediately at maturity.

TYPE SPECIES : *Eriosporangium baccharidis* Bert. on *Baccharis montevidiensis* (Compositae)

DISTRIBUTION : Tropical America and Africa (40 species)

NOTES : Most of the known species occur either on Compositae or Labiatae. There has been considerable difference of opinion as to whether *Eriosporangium* should be separated from *Puccinia*. Dietel (1928) recognises it for species with or very poorly developed peridia in aecia and teliospores with pale or colourless walls, germinating immediately at maturity. There are species intermediate between *Eriosporangium* and *Puccinia* and Mains (1939) contends that that is to be expected for two closely related genera and thinks that *Eriosporangium* should receive generic status. Sydow (1940) has described *Eriosporangum oyedaeae* (Speg.) Syd. which indicates that he recognises the genus as valid.

Jackson (1932) considers that the genus is not natural and it is impracticable to separate it from *Puccinia*. *Ceaomoid* type of aecia given as the diagnostic character of *Eriosporangium* show all range of intermediate conditions and some of the species have well developed peridia. As to teliospores, Jackson points out that there are many species with typical peridiate aecia and thin-walled teliospores. Because of the overlapping of characters he recommends that *Eriosporangium* be merged into synonymy of *Puccinia*, a view with which the writers are in complete agreement.

Arthur, J. C. (1907). North Amer. Fl. **7**: 211
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 79

Jackson, H. S. (1932). *Mycologia* **24**: 131
Mains, E. B. (1939). *Bull. Torrey bot. Cl.* **66**: 175
Sydow, H. (1940). *Ann. mycol.* Berl. **38**: 270

Fig. 46. Frommea

51 **FROMMEA** Arthur in *Bull. Torrey bot. Cl.* **44**, p. 503, 1917 Fig. 46

Pycnia subcuticular, without conspicuous ostiolar paraphyses. Aecia (primary uredia) uredinoid, subepidermal, without peridium or paraphyses. Uredia (secondary uredia) subepidermal, with sparsely developed peripheral paraphyses; urediospores pedicellate, with indistinct germ pores. Telia subepidermal, aparaphysate; teliospores 2 to 7-celled, cinnamon brown, smooth, with one apical germ pore in each cell; germinating without rest period; pedicel hyaline, not swelling in water.

TYPE SPECIES: *Frommea obtusa* (Strauss) Arthur on *Potentilla tormentilla* (Rosaceae)

DISTRIBUTION: North America and Europe (4 species)

NOTES: All the species so far known occur on *Potentilla*. Both Dietel (1928) and Sydow (1921) emphasize the occurrence of aparaphysate primary uredia and secondary uredia with peripheral paraphyses. Dietel states that there are no germ pores but according to Arthur there are 3 to 4 indistinct ones.

Frommea differs from *Phragmidium* in teliospore characters. In *Frommea* they are smooth and have a single apical germ pore in each cell, as against the tuberculate teliospores of *Phragmidium*, which are further distinguished by the presence of more than one germ pore, which are laterally disposed in each cell. The pedicels in the teliospores of *Phragmidium* swell in water whereas those of *Frommea* do not. The absence of caemoid aecia was stressed as one of the distinguishing characters of *Frommea* by Arthur. The practice of separating genera on the basis of the type of life cycle is incorrect.

Arthur, J. C. (1925). North Amer. Fl. **7**: 131
Arthur, J. C. (1934). Manual of Rusts. p. 92
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 61
Sydow, H. (1921). *Ann. mycol. Berl.* **19**: 167

52 **GALLOWAYA** Arthur in *Result. Sci. Congr. Bot. Vienne*, p. 336, 1906 Fig. 47

Pycnia occasionally formed, subepidermal, rudimentary. Aecia and uredia unknown. Telia subepidermal, flat, erumpent, often forming conspicuous spore columns; teliospores 1-celled, developed in basipetal succession, germinating by an internal 4-celled promycelium.

TYPE SPECIES: *Gallowaya pinicola* (Galloway) Arthur on *Pinus virginiana* (Coniferae)

DISTRIBUTION: North America (2 species)

NOTES: A short discussion on the genus has already been given under *Coleosporium*. The genus is not merely a cyclic variant of *Coleosporium* as construed by Arthur (1934) who merged *Gallowaya* as a synonym of *Coleosporium*. The

Fig. 47. Gallowaya

catenulate development of the teliospores is a very distinguishing character which feature is very pronounced in *Gallowaya crowelli* (Cummins) n. comb. (=*Coleosporium crowelli* Cummins) where the teliospores occur in chains of 10 to 12 spores and form a columnar telium.

Arthur, J. C. (1907). North Amer. Fl. **7** : 95

Arthur, J. C. (1934). Manual of Rusts p. 46-47

Cummins, G. B. (1938). *Phytopathology* **28** : 522-523

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 46

Dodge, B. O. (1928). *J. agric. Res.* **31** : 641-651

Sydow, H. & P. (1915). Monogr. Ured. III : 657-658

53 **GAMBLEOLA** Massee in *Bull, Misc. Inform. Kew.* p. 115, 1898 Fig. 48

Pycnia subepidermal, deeply sunk in the host tissue. Aecia and uredia unknown. Telia subepidermal, deeply sunk, cupulate, developing elongate, filiform spore tendrils which are dry, horny and brownish-black ; teliospores formed successively from the basal hymenium, developed in chains, laterally coalescent to form a firm spore column ; outermost layer of sterile cells constituting the peridium ;

spores 2-celled, reddish-brown, alternating with sterile intercalary cells in the chain, with 2 germ pores in each cell, apical in the upper and lateral in the lower ; promycelium external and typically 4-celled.

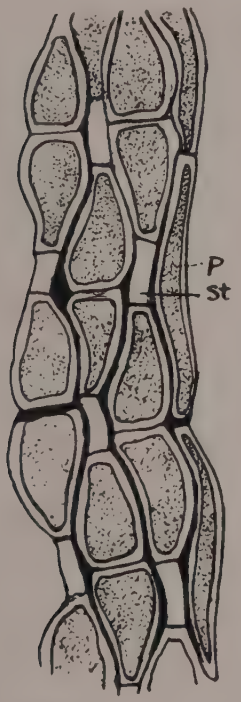


Fig. 48.m Gaeoba
p = Peridium
St. = Sterile intercalary cell

TYPE SPECIES : *Gambleola cornuta* Massee on *Berberis nepalensis* (Berberidaceae)

DISTRIBUTION : India (one species)

NOTES : *Gambleola* is a monotypic genus forming *Cronartium*-like spore tendrils on the leaves of *Berberis nepalensis*. Jackson (1931) suggests that microcyclic rusts like *Didymopsora*, *Pucciniosira* and *Gambleola* are drived from *Endophyllum*—like forms, possibly by the lateral coalscence of the spore-chains. As evidence, he demonstrated the occurrence of sterile intercalary cells in *Gambleola* which had been overlooked previously. This has been confirmed by Thirumalachar (1947) who has traced the development of the spore chains. The genus is closely related to *Pucciniosira* where 2-celled teliospores are produced in chains and are often separated from each other by sterile intercalary cells. Its telia are also peridiate. But the teliospore-chains in *Pucciniosira* are not permanently coalesced to form *Cronartium*-like spore columns and the spores get easily separated. The teliospores are hyaline as against the deeply coloured ones in *Gambleola*.

Butler, E. J. (1905). *Indian Forester*, p. 32

Dietel, P. (1928). Die natürlichen Pflanzenfamilien. **6** : 94

Jackson, H. S. (1931). *Mem. Torrey bot. Cl.* **18** : 1-108

Sydow, H. & P. (1915). Monogr. Ured. III 584

Thirumalachar, M. J. (1947). *Mycologia* **39** : 231-248

54 **GERWASIA** Raciborski in *Bull. Acad. Sci. Cracovie, Classe Sci. Math. et Nat.* 1909, p. 270 Fig. 49

Pycnia, aecia and uredia unknown. Telia subepidermal, minute ; teliospores arising from several stalk cells (4 to 15) at the apex of a single large sporiferous hyphal cell emerging through the stomata ; spores 1-celled, globose, smooth, germinating at once by a 4-celled external promycelium bearing globular sporidia.

TYPE SPECIES : *Gerwasia rubi* Racib. on *Rubus* sp. (Rosaceae)

DISTRIBUTION : Java, Philippines (2 species)

NOTES : Only the telial stage is known, the teliospores developing superstomally at the apex of a single sporogenous hyphal cell, borne on short pedicels. Arthur and Cummins (1936) who described a second species found marginal, incurved apraphyses developing from the same sporogenous hyphlal cell. They found intra-

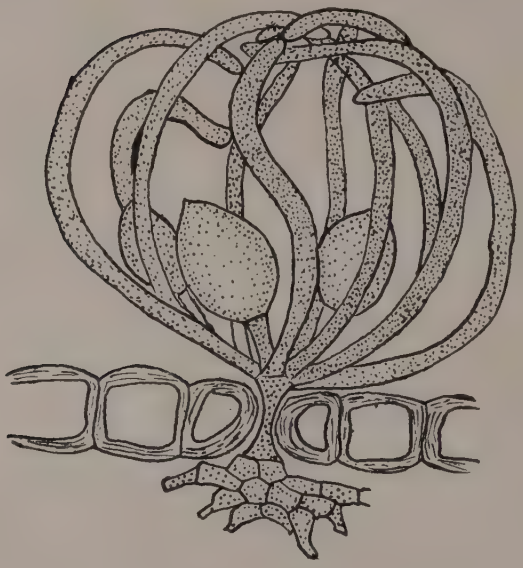


Fig. 49. Gerwasia

epidermal uredia within the hypertrophied epidermal cells, associating with the telia. They doubtfully assign the species to *Gerwasia* rather that to *Mainsia* which genus, they say, may prove to be synonymous with *Gerwasia*. Unless the type specimen of *Gerwasia rubi* is restudied, the matter cannot be decided once for all. The type is stated to be at the Botanical Institute, Jagellonian University, Krakow, Poland.

Mainsia was established by Jackson (1931) for long-cycled rusts on *Rubus* including both intra-epidermal and superstomal forms, the latter being indistinguishable from published descriptions of *Gerwasia*. The differences between intra-epidermal and superstomal forms of *Mainsia* are so slight that their separation into separate genera appears to be unwarranted.

Arthur, J. C. and Cummins, G. B. (1936). *Philip. J. Sci.* **61** : 466-467

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 51

Jackson, H. S. (1931) *Mycologia* **23** : 106

Sydow, H. & P. (1915). Monogr. Ured. III : 203

55 *GOPLANA* Raciborski in *Paras. Algen u-Pilze Javas* II, p. 24 1900 Fig. 50

Pycnia and aecia unknown. Uredia subepidermal, deep seated. Telia subepidermal, minute, waxy or mostly gelatinous ; teliospores cylindrical, sessile ; several teliospores developed in succession from the sporogenous basal cells and embedded in the gelatinous matrix ; spores germinating to form a 4-celled internal promycelium developing sporidia on long sterigmata.

TYPE SPECIES : *Goplana mirabilis* Racib. On *Meliosma* (Sabiaceae)

DISTRIBUTION : Java, Philippines, India (6 species)

Fig. 50. Goplana

NOTES: Uredia were first described by Cummins (1935). Teliospores germinate by an internal promycelium and bear sporidia on long sterigmta which protrude out of the gelatinous matrix. The occurrence of the gelatinous matrix in the telium differentiates the genus from the closely related genera such as *Chrysella* and *Achrotelium*.

Cummins, G. B. (1935). *Mycologia* **27** : 607

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 55

Sydow, H. & P. (1915). Monogr. Ured. III : 674-657

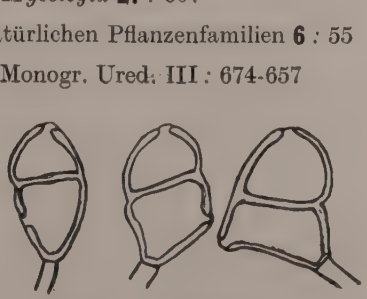


Fig. 51. Gymnoconia

56 **GYMNOCONIA** Lagerheim in *Tromsö Mus. Aarsh.* **16**, p. 140, 1894 Fig. 51

Pycnia subcuticular, conoid, without conspicuous ostiolar paraphyses. Aecia caemoid, without peridia or paraphyses ; aeciospores catenulate. Uredia unknown. Telia minute, subepidermal ; teliospores *Puccinia*-like, 2-celled, ellipsoid to oblong, pedicellate, with one germ pore in each cell.

TYPE SPECIES : *Gymnoconia interstitialis* (Schlecht). Lagerh. on *Rubus* sp. (Rosaceae)

DISTRIBUTION : Europe, North Asia and North America (2 species).

NOTES : The species so far known occur on *Rubus* and *Alchimilla*. Pycnia are subcuticular, other spore forms being subepidermal. Lagerheim remarks that *Gymnoconia* shows relation to *Puccinia* and *Phragmidium*. Teliospores are typical of *Puccinia* in being 2-celled with a single apical germ pore in each cell. On the other hand the subcuticular pycnia and caeomoid aecia are characteristic features of *Phragmidium*. The absence of paraphyses in the caeoma is noteworthy.

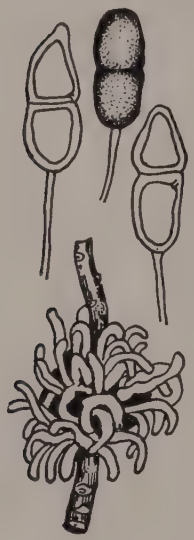


Fig. 52
Gymnosporangium

Short-cycling tendencies in the life cycle have been reported in *Gymnoconia interstitialis*. According to Kunkel (1920), late in the season, the aeciospores germinate by a promycelium bearing sporidia in place of simple germ tubes, aeciospores assuming the function of teliospores.

Arthur, J. C. (1912). North Amer. Fl. **7** : 180
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 59
Kunkel, L. O. (1920). *J. agric. Res.* **19**. 501-512
Sydow, H. & P. (1915). Monogr. Ured. III : 82

57 **GYMNOSPORANGIUM** Hedwig. f. Apud DC. *Fl. Fr.* II, p. 26, 1805 Fig. 52

Cancellaria Brong. Essai Classif. Nat. Chanep. p. 32, Syn. 1825

Centridium Chev. *Fl. General Environs Paris* I, p. 383, 1826

Ceratitium Rabenh. *Bot. Ztg*, **9** : 447, 1833

Ciglides Chev. *Fl. General Environs Paris* I, p. 383, 1826

Gymnotelium Sydow. *Ann. mycol.* **19** : 170Berl. 1921

Podiosma Link, *Mag. Ges. naturf. Freunde* 3, p. 350, 1809

Roestelia Rebentisch, *Prodr, Fl. Neomarch.* p. 350, 1804

Pycnia subepidermal, deep seated, with ostiolar filaments. Aecia subepidermal, erumpent, mostly with cylindric or cornute peridium tending to rupture by longitudinal slits along the sides ; peridial cells imbricated, often articulated, occasionally hygroscopic and becoming curved when wet, thin on the contiguous side and with verruculose or wart-like protruberences on the free side; aeciospores globoid, coloured, with evident germ pores. Uredia when present subepidermal and aparaphysate. Telia subepidermal, erumpent, naked, variously shaped, gelatinous and elastic, naked at maturity, expanding considerably when moistened ; teliospores chiefly 2-celled, rarely 3 to 4 or even 5 celled by transverse septa ; walls coloured, with usually 2 germ pores in each cell, rarely 1, 3 or 4 ; pedicels hyaline, elastic, usually of considerable length, cylindric, thick-walled, the outer portions swelling and becoming gelatinized in moisture to form jelly-like matrix in which spores lie embedded.

TYPE SPECIES : *Gymnosporangium conicum* Hedwig f. said to be on *Juniperus communis* and *Juniperus sabina* (Juniperaceae)

DISTRIBUTION : Wide spread (40 species)

NOTES : Heteroecious rusts with telial stage on Juniperaceae and aecial stage on Malaceae (apple family). Recently the aecial stage has also been found on species belonging to the Rosaceae, Hydrangiaceae and Myricaceae while the telial stage has never been outside the Juniperaceae. While the majority of species have cylindric or cornute aecia, some of the apple family have cupulate aecia. Uredia are known only on *Gymnosporangium nookatense* and absent in others. Recent studies on *Coleopuccinia* by Tai (1948) have shown that the pedicels of the telia gelatinze in the same manner as in *Gymnosporangium*. The teliospores are, however, one-celled.

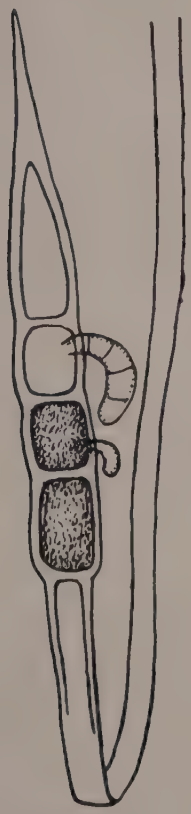


Fig. 53
Hamaspora

Arthur, J. C. (1907). North Amer. Fl. **7** : 188
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 75-77
Kern, F. D. (1911). *Bull. New York bot. Gdn.*, **7** : 391-483
Sydow, H. & P. (1916). Monogr. Ured. III : 3
Tai, F. L. (1948). *Acta Agriculturae* (China), **1** : 97-103

58 **HAMASPORA** Koernicke in *Hedwigia*, **16**, p. 22, 1877
Fig. 53

Syn. *Hamasporella* v. Hoehnel, *Z. Gar. Physiol.* I, p. 226, 1912

Pycnia subcuticular, minute, without conspicuous ostiolar paraphyses. Aecia unknown. Uredia sub-epidermal, paraphysate ; paraphyses cylindric, incurved, hyaline or with orange-yellow contents. Telia sub epidermal, caespitose, filiform or pustuliform, standing together in thick matty groups, as a result of intertwining of pedicels and producing vermicularly curved or weakly gall-like bodies up to 5 mm. long, golden yellow when fresh and later pale ; teliospores 2 to 6-celled, spindleshaped, smooth ; almost hyaline membrane, without distinct germ pores ; germinating without rest period ; pedicels hyaline, long, slightly gelatinous.

TYPE SPECIES : *Hamaspora longissima* (Thuemen) Koern. on *Rubus*. (lectotype selected by Sydow)

DISTRIBUTION : South Africa, India, Australia, Java and the Philippines (6 species)

NOTES : All are autoecious and occur on *Rubus*. Koernicke established the genus on two species, *Hamaspora ellisii* and *Hamaspora longissima*. The former is now included in *Gymnosporangium*. The genus is distinguished from *Phragmidium* and *Frommea* by its long, thread-like or spindle-shaped colourless teliospores and in germ pores being indistinct in this genus. The type of teliospore sometimes resembles that of *Gymnosporangium* but in the latter genus there are more than one germ pore in each cell of the teliospore and pycnia are subepidermal in contrast to the subcuticular pycnia of *Hamaspora*.

In describing the genus *Mimema* Jackson (1931) states that it is closely parallel to *Hamaspora* which, however, is known only on *Rubus*. He therefore sets apart

the genus *Mimema* for those species on Leguminosae (as *Mimema holwayi* is on *Cassia versicolor*). A genus cannot be segregated merely on the basis of the host group. *Mimema* stands out as a separate genus on its own characters. Uredial paraphyses are not developed from the base of the sorus as in *Hamaspora* but they arise from hyphal cells at the mouth and sides of the sorus and resemble those of *Cerotelium*. Secondly the teliospores of *Mimema* are not spindle-shaped and thread-like but resemble those of *Sorataea* (*Allopuccinia*), with this difference that they are more than 2-celled. Thirumalachar and Cummins (1948) have shown that occasionally 3-celled teliospores are found in *Sorataea amiciae*, the type of the genus, which brings it closer to *Mimema*. We therefore disagree with Jackson's view that *Mimema* is only a host-group segregate of *Hamaspora*.

Arthur, J. C. (1912). North Amer. Fl. **7** : 188
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 61
Doidge, E. M. (1926). *Bothalia* **2** : 8
Jackson, H. S. (1931). *Mycologia* **23** : 332-364
Sydow, H. & P. (1915). Monogr. Ured. III: 77
Thirumalachar, M. J. and Cummins, G. B. (1948). *Mycologia* **40** : 417-422

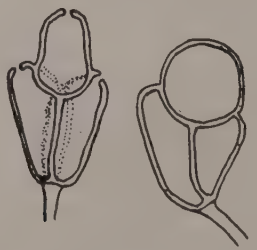


Fig. 54. Hapalophragmium

59 **HAPALOPHRAGMIUM** Sydow in *Hedwigia* **40**, p. 64, 1901 Fig. 54

Syn. *Triactella* Sydow, *Ann. Mycol.* **19** : 19, 1921

Pycnia subcuticular, conoid, without conspicuous ostiolar paraphyses. Aecia uredinoid, developed on hypertrophied spots, subepidermal, deeply sunk, paraphysate ; aeciospores resembling urediospores. Uredia subepidermal, with or without marginal incurved paraphyses ; urediospores pedicellate and with evident germ pores. Telia resembling uredia ; teliospores pedicellate, 3-celled, odd-spore terminal and two basal cells borne on a common pedicel ; with a single apical germ pore in each cell.

TYPE SPECIES : *Hapalophragmium derridis* Sydow on *Derris ulignosa* (Leguminosae)

DISTRIBUTION : South Africa, Sierra Leone, India, Philippines, Indo-China (8 species).

NOTES : Teliospores in this genus are three-celled but the odd spore is terminal with the two lower basal ones being borne on a common pedicel, in contrast to *Triphragmium* where the odd-spore is basal and is attached to the pedicel. There is a single apical germ pore in each cell of the teliospore of *Hapalophragmium* in contrast to more than one in *Nyssopsora* and *Triphragmiopsis* which also have 3-celled teliospores.

Only uredia and telia were known for the genus. In *Hapalophragmium pondersum*, the gall forming rust on *Acacia leucophloea* described by Sydow and Butler (1912), subepidermal pycnia were found by Thirumalachar (1941). In a recent study of *Hapalophragmium mysorensis* on *Derris benthami*, Thirumalachar (1950) noted subcuticular pycnia and subepidermal uredinoid aecia developing on hypertrophied patches. *Hapalophragmium* species so far known to parasitize species of *Derris*, such as *Hapalophragmium derridis*, *Hapalophragmium setulosum*, *Hapalophragmium pulchra*, *Hapalophragmium annamalaiensis* and *Hapalophragmium mysorensis* form a closely intergrading series with overlapping characters, such as paraphyses in uredia and telia, warts near the germ pore of the teliospores, relative sizes of teliospores and urediospores. As *Hapalophragmium derridis* is the type of the genus, Thirumalachar (1950) considered the finding of sub-cuticular pycnia and uredinoid aecia as representing the characters of the genus *Hapalophragmium*. Since the gall forming *Hapalophragmium pondersum* has subepidermal pycnia and hence a different type of sorus structure, it was placed under a separate genus, *Hapalophragmiopsis* Thirumalachar. Species of *Hapalophragmium* so far known are all on the Leguminosae. The genus *Triactella* founded by Sydow with *Triactella pulchra* on *Derris elliptica* as type, and which has been recognised by Dietel (1928), has been merged into the synonymy of *Hapalophragmium* by Sydow and Petrak (1931). Jackson (1931) added another species, *Triacetella holwayi* on *Cassia* sp. but from its description appears to be a species of *Triphragmium*.

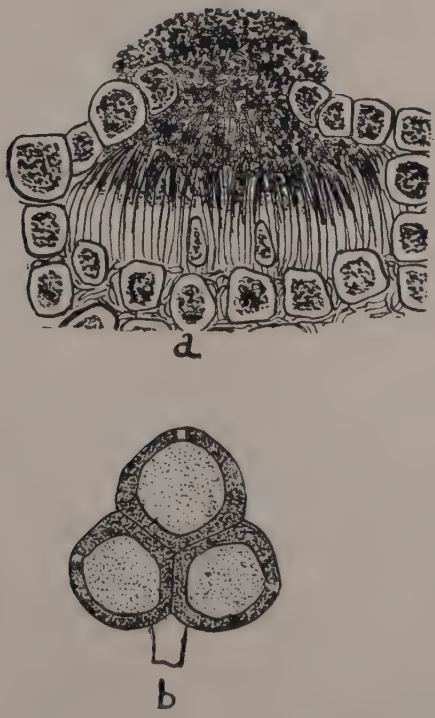


Fig. 55. Hapalophragmiopsis

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 69
Jackson, H. S. (1931). *Mycologia* **23** : 341-342
Sydow, H. & P. and Butler, E. J. (1921). *Ann. mycol. Berl.* 10 : 243-280
Sydow, H. & P. (1915). Monogr. Ured. III : 182
Sydow, H. and Petrak F. (1931). *Ann. mycol. Berl.* **29** : 160-161
Thirumalachar, M. J. (1941). *J. Indian bot. Soc.* **20** : 293-298
Thirumalachar, M. J. (1950). *Mycologia* **42** : 224-232

60 **HAPALOPHRAGMIOPSIS** Thirumalachar in *Mycologia* **42** : p. 227, 1950 Fig. 55

Pycnia subepidermal, conoid, without conspicuous ostiolar paraphyses. Aecia and uredia unknown. Telia subepidermal, erumpent, aparaphysate ; teliospores pedicellate, 3-celled, odd spore being terminal as in *Hapalophragmium*, yellowish brown with a single germ pore in each cell of the teliospore ; pedicel hyaline and deciduous.

TYPE SPECIES : *Hapalophragmiopsis ponderosum* (Sydow & Butler) Thirumalachar on *Acacia leucophloea* (Leguminosae)

DISTRIBUTION : India (1 species)

NOTES : As already stated under *Hapalophragmium*, the genus *Hapalophragmiopsis* was set up to accomodate forms with subepidermal pycnia in contrast to the subcuticular condition in the former. *Hapalophragmium acaciae* Baccarini on *Acacia* sp. is a gall forming rust in Somaliland and is stated to be closely related to *Hapalophragmium poderosum*. This may also prove to be a *Hapalophragmiopsis* when its pycnial stage is discovered.

Sydow, H. & P. and Butler, E. J. (1912). *Ann. mycol. Berl.* **10** : 243-280
Thirumalachar, M. J. (1941). *J. Indian bot. Soc.* **20** : 293-298

Fig. 56. Haplopyxis

61 **HAPLOPYXIS** Sydow in *Ann. mycol. Berl* **17**, p. 105, 1919 Fig. 56

Pycnia and aecia unknown. Uredia subepidermal, erumpent, aparaphysate ; urediospores borne singly on pedicels; wall coloured, echinulate, with 6 to 8 scattered germ pores. Telia subepidermal, erumpent ; teliospores 1-celled, sparsely verruculose, wall laminate, inner layer firm and coloured, outer layer translucent and gelatinous, overlaid by the thick cuticle, with two laterally situated germ pores.

TYPE SPECIES : *Haplopyxis crotalariae* (Arth.) Sydow on *Crotalaria vitellina* (Leguminosae)

DISTRIBUTION: Guatemala, Brazil, possibly other South American countries (one species)

NOTES: The rust was first described by Arthur (1918) as *Uropyxis crotalariae* on material collected by Holway. He stated that it was the first species of *Uropyxis* with one-celled teliospores. Sydow made it the type of a separate genus, *Haplopyxis*, which differs from *Uropyxis* in the same way that *Uromyces* differs from *Puccinia*.

Arthur, J. C. (1918). *Amer. J. Bot.* **5**: 429-430
Arthur, J. C. (1925). North Amer. Fl. **7**: 724
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 65

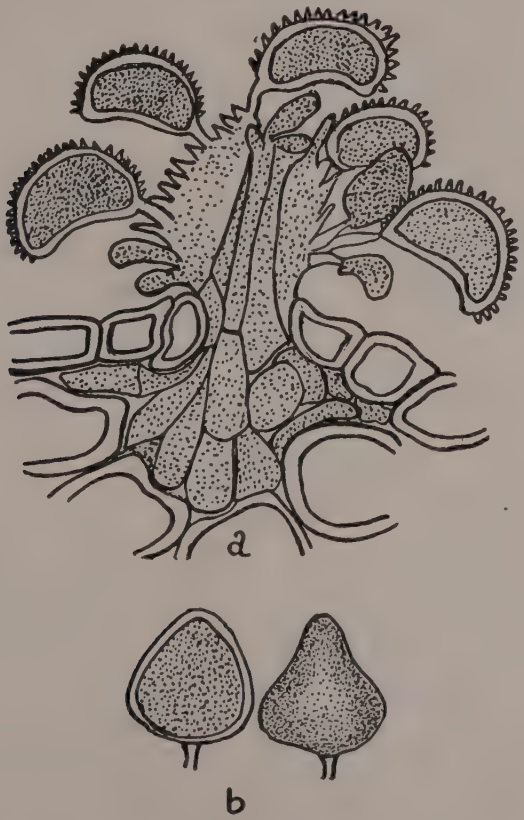


Fig. 57. Hemileia. a. Urediospores. b. Teliospores

62 **HEMILEIA** Berkely & Broome in *Gardner's Chronicle*, 1869, p. 1157 Fig. 57

Syn. *Hemileiopsis* Raciborski, Paras. Algen u. Pilze Javas I, p. 25, 1900

Pycnia and aecia unknown. Uredia minute, superstomal, rarely subepidermal, urediospores borne in clusters on short pedicels or sterigmata at the apex of sporogenous sporophores, emerging through the stomata; sporophores few to many, dis-

tinctly separate in early stages, later showing lateral coalescence ; urediospores bifacially ovate to reniform, smooth on the lower flat side and covered with dense aculeate processes on the convex side. Telia like uredia ; teliospores borne in clusters at apices of sporogenous sporophores on short stalks, ovate, napiform, crescentic or tridentate, orange-yellow when fresh; epispore thin, hyaline, without germ pores ; germinating immediately at maturity by the prolongation of spore-spex ; promycelium external and four-celled.

TYPE SPECIES : *Hemileia vastatrix* Berk & Br. on *Coffea* sp. (Rubiaceæ)

DISTRIBUTION : India, Ceylon, Phillippines, Java, South Africa, Central America (31 species)

NOTES : Plants belonging to several orders of dicots and monocots are parasitised. Species can be recognised even in the absence of telia because of the superstomal structure of the uredia and characteristics of the urediospores. A detailed account of the uredia and telia was given by Thirumalachar and Narasimhan (1947). They pointed out that the fasciculate hyphæ emerging through the stomata are sporogenous sporophores rather than pedicels as misconstrued by some of the earlier investigators. Regarding the structure of the sorus, there is a good deal of resemblance between *Hemileia* and *Gerwasia* (as described by Raciborski) and *Cystopsora*. In *Gerwasia* only a single sporogenous hypha emerges out of the stoma and in *Cystopsora* teliospores germinate by a semi-internal promycelium. The sculpturing of the urediospores is so chracteristic that it is doubtful whether students of rusts would recognise a *Hemileia* species on the basis of telia alone.

Thirumalachar (1943) pointed out that in *Hemileia canthii* the mycelium in the substomal spaces becomes closely septate and rounded off into urediospores or teliospores, thus developing a sub-epidermal sorus covered by the epidermis. This is reminiscent of the condition present in the smuts.

Arthur, J. C. (1907). North Amer. Fl. **7** : 149)

Dietel, J. C. (1923). *Ann. mycol. Berl.* **21** : 86

Dietel, P. (1928). Die natÜrlichen Pflanzenfamilien **6** : 52

Sydow, H. & P. (1915). Monogr. Ured. III : p. 205

Thirumalachar, M. J. (1943). *J. Indian bot. Soc.* **22** : 225-228

Thirumalachar, M. J. and Narasimhan, M. J. (1947). *Ann. Bot.* (*n. s.*) **11** : 77-89

63 **HYALOPSORA** Magnus in *Ber. dtsch. bot. Ges.* **19** : 582, 1901 Fig. 58

Pycnia hypophyllous, minute, subepidermal. Aecia hypophyllous, subepidermal, cylindrical, ruptured at the apex ; peridia colourless, delicate, firm ; aeciospores globose to ellipsoidal, coloured. Uredia amphigenous, minute, subepidermal ; peridia rudimentary, or well developed, or bordered by marginal paraphyses ; urediospores sessile, obovate, with coloured contents ; walls colourless, minutely verruculose, smooth, with equatorial germ pores ; amphispores associated, large, with thick walls. Telia mostly hypophyllous, indehiscent, with teliospores produced within the cells of the epidermis and vertically septate ; walls colourless ; germinating without a rest period ; promycelium external and 4-celled.

TYPE SPECIES : *Hyalopsora aspidotus* (Peck) Magn. on *Phegopteris dryopteris* (L.) Fee has been selected as the *lecto-type* by Arthur

DISTRIBUTION : Europe, North America, Siberia, Japan (9 species)

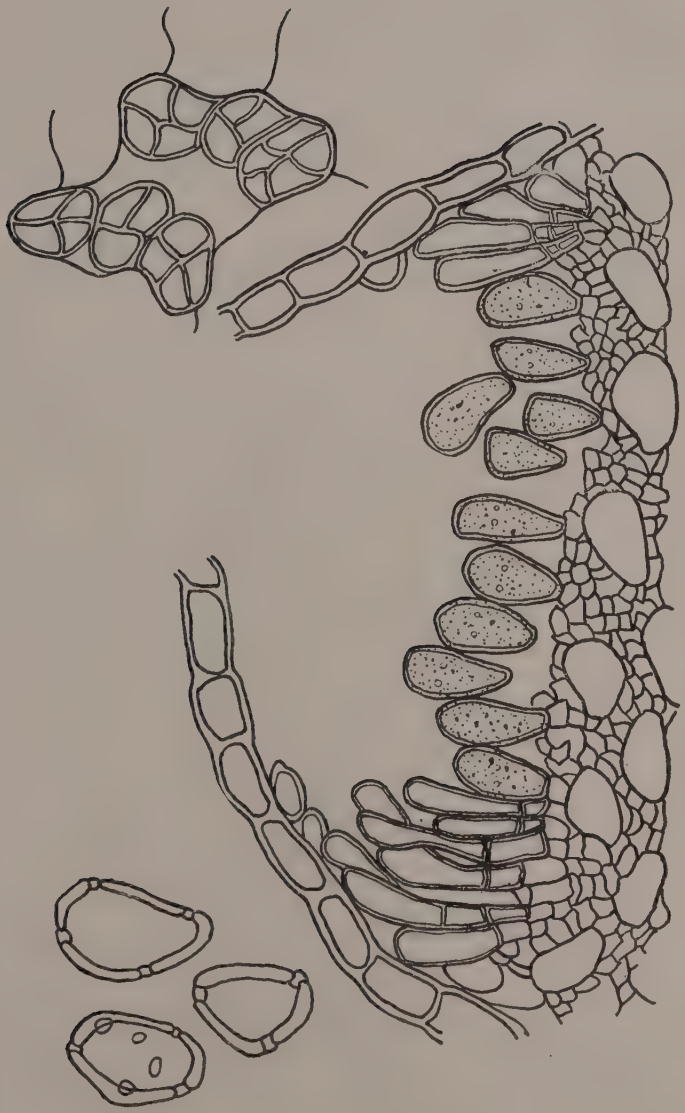


Fig. 58. Hyalopsora

NOTES: Hetercœcious rusts with pycnia and aecia on conifers and uredia and telia on ferns. The genus is distinguished from the other rusts on ferns by the golden yellow, pulverulent urediospores. Uredia in some cases are without peridium and may be surrounded by septate, hyaline, paraphyses. These are considered as such by Magnus and Sydow but Liro, Arthur and Dietel consider them as a sort of pseudoperidium.

Hyalopsora produces two kinds of urediospores : thin walled spores that germinate at once ; and thick walled amphispores which germinate only after a time. The latter do not have a diagnostic value for they are not always present. The presence of equatorial germ pores in some of the species was pointed out by Cummins to be a unique feature for a rust genus of Melampsoraceæ.

Arthur, J. C. (1907). North Amer. Fl. **7** : 112

Cummins, G. B. (1936). *Mycologia* **28** : 111-127

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 37

Sydow, H. & P. (1915). Monogr. Ured. III : 493-495.

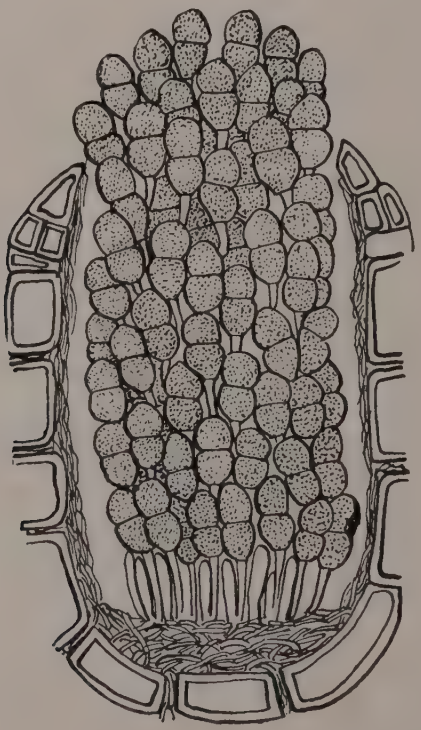


Fig. 59. Kernella

64 **KERNELLA** Thirumalachar in *Mycologia* **41**, p. 97, 1949 Fig. 59

Syn. *Kernia* Thirumalachar, (*not Kernia* Nieuwland), *Mycologia* 38 : 679-686, 1946

Pycnia, aecia and uredia unknown. Telia subepidermal, erumpent, deep-seated, without peridia or paraphyses; teliospores 2-celled, *Puccinia*-like, pedicellate, developing in succession from the basal hymenium; teliospores not catenate, but younger spores developing in-between the older ones, adhering laterally to one another; spore-mass emerging in long, semi-permanent *Cronartium*-like spore-tendrils, 10 to 15 mm. long; mature spores germinating without a rest period; promycelium external, 4-celled.

TYPE SPECIES: *Kernella lauriocola* Thirumalachar on *Litsea* sp. (Lauraceæ)

DISTRIBUTION: India (1 species)

NOTES: Two-celled pedicellate teliospores produced in succession and forming semi-permanent *Cronartium*-like columns also occur in *Gambleola*. But in the latter the teliospores are developed in definite chains and there is a definite peridial layer. Telial horns occur in *Gymnosporangium* in which teliospores are embedded in galatinous matrix and the type of telial structure is different. The structure of the telium and the arrangement of teliospores in the spore columns are similar to *Chardoniella* described by Kern (1939) but the teliospores are 1-celled as against 2-celled teliospores in *Kernella*.

Kern, F. D. (1939). *Mycologia* **31**: 375

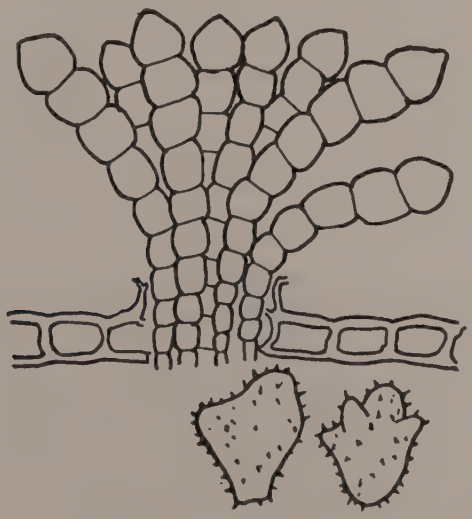


Fig. 60. Kueheola

65 **KUEHNEOLA** Magnus in *Bot. Zbl.* **74**, p. 169, 1898 Fig. 60

Syn. *Spirechina* Arthur, *J. Mycol.* **13**: 30, 1907

Pycnia subcuticular, flattened, conoid, without conspicuous ostiolar paraphyses. Aecia unknown. Uredia subepidermal, erumpent, without peridium, with or without paraphyses; urediospores globose to ellipsoid, pedicellate or sessile, with 2 to 3

indistinct germ pores. Telia minute, compact, rather waxy; teliospores unicellular, hyaline, developing in chains in basipetal succession ; chains with varying number of spores, falling apart, with a single apical germ pore in each cell ; spores germinating without a rest period, immediately at maturity ; promycelium external, four-celled exerted through the germ pore.

TYPE SPECIES : *Phragmidium albidum* (Kuehn) Ludw. (*Chrysomyxa albida* Kuehn)

DISTRIBUTION : Widespread (6 species)

NOTES : Separation of the genus *Kuehneola* from *Cerotelium* has resulted in a good deal of confusion. Early literature indicates several transfers of species from one genus to another without definite basis. Dietel (1912) restricted *Kuehneola* to forms occurring only on *Rubus* and *Rosa* and transferred others to *Cerotelium*. He further stressed the aparaphysate nature of the uredia and telia. This concept is untenable since it is not advisable to base generic status on the suscept or host groups. In addition, Cummins (1940) has shown that in *Kuehneola papuana* on *Rubus* sp., the telia are paraphysate.

As stated under *Cerotelium*, the uredial and telial characters offer the basis for the separation of the genera. The phakopsoroid type of uredia with hyaline spores are lacking in *Kuehneola* where they are pedicellate and possess germ pores. The telial chains are laterally free and fall apart in *Kuehneola* whereas in *Cerotelium* they form short columns at the base due to the lateral coalescence of the spore chains, becoming pulverulent at the apex. With respect to the type of spore chains, there is close resemblance between *Catenulopsora* and *Kuehneola*. In the former genus the promycelium is formed by the prolongation of the beaked spore apex while in the latter it is exserted through a distinct germ pore.

Arthur, J. C. (1907). North Amer. Fl. **7** : 184 and 730
Cummins, G. B. (1940). *Mycologia* **32** : 369
Dietel, P. (1912). *Ann. mycol. Berl.* **10** : 205-207
Dietel, P. (1928). Die natürlichen Pflanzenfamilien 6 : 60
Sydow, H. & P. (1915). Monogr. Ured. III : 313

66 **KUNKELIA** Arthur in *Bot. Gaz.* **43** p. 504, 1917

Pycnia subcuticular, conoid, without conspicuous ostiolar paraphyses. Aecia and uredia unknown. Telia without a peridium, or paraphyses ; teliospores catenulate, 1-celled ; wall colourless, verruculose with scattered germ pores ; spores germinating immediately at maturity.

TYPE SPECIES : *Kunkelia nitens* (Schw.) Arthur on *Rubus* Sp. (Rosaceae)

DISTRIBUTION : North America (2 species).

NOTES : Only pycnia and caemoid telia are known. The telia resemble the aecial stages of *Gymnoconia* from which it is indistinguishable morphologically and germination studies are necessary for accurate determination. Kunkel (1920) found that the æciospores of *Gymnoconia interstitialis* occasionally germinate late in the season by a promycelium rather than simple germ tubes, which character has become a normal feature in *Kunkelia*. Dodge (1924) found that in the cæoma of the *Kunkelia* type spores germinating by promycelium and simple germ tubes are associated in the same sorus. From these it is evident that *Kunkelia* is really only an endorform of *Gymnoconia* and yet it is usually held as a separate genus by most of the uredinologists. Theoretically any cæmoid æcium whose spores germinate by a promycelium and sporidia could be referred to *Kunkelia*, just as any cupulate and peridiate aecium

can be referred to *Endophyllum* if germination takes place by a promycelium. It seems therefore desirable to maintain such genera for the same reason that form genera are useful.

Arthur, J. C. (1926). North Amer. Fl. **7** : 731
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 59
Dodge, B. O. (1924). *J. agric. Res.* **28** : 1045-1058
Kunkel, L. O. (1920). *J. agric. Res.* **19** : 501-512

67 **LEUCOTELIUM** Tranzschel in *Riv. Patol. Veg.* **25**, p. 183, 1935 and *Sovetsk. Bot.* **4** : 83, 1935

Pycnia subcuticular, applanate, conoid. Aecia subepidermal, cupulate and peridiate, and resembling those of *Tranzschelia* ; peridia reflexed and lacerate in later stages ; æciospores developing in chains. Uredia subepidermal, aparaphysate; urediospores borne singly, with distinct germ pores. Telia subepidermal, erumpent; teliospores pedicellate, 2-celled and *Puccinia*-like, hyaline ; germinating immediately at maturity ; promycelium external and 4-celled.

TYPE SPECIES : *Leucotelium cerasi* (Cast.) Tranzschel

DISTRIBUTION : Far east of U. S. S. R. (2 species)

NOTES : *Leucotelium cerasi* and *Leucotelium padi*, the two species so far known, are both heterœcious with pycnial and aecial stages on *Eranthis* sp. (Ranunculaceæ). The genus was separated from *Puccinia* on account of the subcuticular pycnia and hyaline teliospores. That these characters are duplicated in *Soratœa*, a genus described by Sydow (1930), has been pointed out by Thirumalachar and Cummins (1948). They however state that until additional species are described and more information is available concerning these two genera, it appears inadvisable to reduce *Leucotelium* to synonymy. Further comparative studies made by the senior author have shown differences in the uredial structure of the two genera. In *Leucotelium* the uredia are subepidermal, aparaphysate and erumpent. In *Soratœa amiciae*, the type of the genus, the uredia appear to be formed as in *Olivea* and *Crossopsora*. There is a basket of paraphyses surrounding the sorus which in the initial stages is subepidermal and later on formed above the epidermis and thus appearing superficial.

Sydow, H. (1930). *Ann. mycol. Berl.* **28** : 432-447
Thirumalachar, M. J. and Cummins, G. B. (1948). *Mycologia* **40** : 418

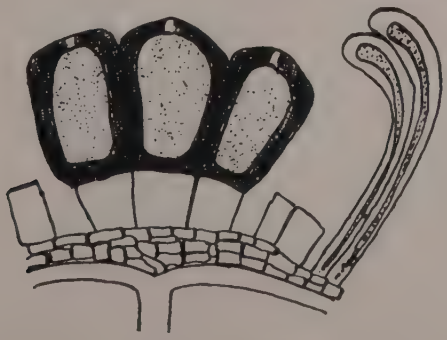


Fig. 61. Lipocystis

68 **LIPOCYSTIS** Cummins in *Bull. Torrey bot. Cl.* **64** : p. 39, 1937 Fig. 61

Pycnia subcuticular without conspicuous ostiolar paraphyses. Aecia uredinoid, without peridium ; æciospores produced singly on pedicels with germ pores. Uredia resembling æcia. Telia amphigenous, subcuticular paraphysate ; teliospores unicellular, produced singly at the apex of pedicels, free amongst themselves or sometimes slightly joined, forming small telial heads with one germ pore in each ; cysts wanting. Germination unknown.

TYPE SPECIES : *Lipocystis cæsalpiniæ* (Arthur) Cummins on *Mimosa ceratonia* (Mimosæ)

DISTRIBUTION : West Indies (1 species)

NOTES : The genus is closely related to *Ravenelia* but differs in having no cysts. Teliospores show a tendency to produce irregularly laterally united clusters of spores reminiscent of *Ravenelia*. The spores arise from a cellular sheet of one to three cells thickness which is the case in subcuticular species of *Ravenelia* also. This sheet appears to be a definite tissue underlying the entire sorus. The pedicel remains attached to the tissue and the tendency to form irregular clusters of united spores seems to be due to this continued connection rather than to an actual adherence of the spores themselves.

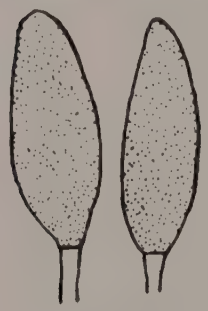


Fig. 62. Mainsia

69 **MAINSIA** Jackson in *Mycologia* **23**, p. 106, 1931 Fig. 62

Pycnia subepidermal, lenticular, without ostiolar paraphyses. Aecia uredinoid ; aeciospores resembling the urediospores and developed on pedicels. Uredia hypophyllous, developed within the hypertrophied epidermis or superstomal, usually aparaphysate ; urediospores pedicellate. Telia similar to uredia, with or without paraphyses ; teliospores 1-celled, colourless, ovate-ellipsoid to clavate ; cylindric, thin-walled, pedicellate and germinating immediately at maturity.

TYPE SPECIES : The generic name *Mainsia* was proposed as a substitute for *Spirechina* Arthur, since the type of the latter was found to be a species of *Kuehneola*. No type was designated by Jackson.

DISTRIBUTION : North and South America, Europe, East Asia (17 species, all on species of *Rubus*)

NOTES : As already stated, *Mainsia* was proposed as a substitute name for *Spirechina* (=*Kuehneola*). The 1-celled hyaline teliospores of *Mainsia* are distinct from catenulate spores of *Spirechina loeseneriana* (the type of *Spirechina*). The sori in most of the forms are intra-epidermal, the hymenium being grouped within the cavities formed by the hypertrophied epidermal cells. In few of the species the sori are superstomal without causing rupture of the epidermis. As already stated before, these forms are similar to the telial stages of *Gerwasia*. Arthur and Cummins (1936) have pointed out that *Mainsia* may have to be merged with *Gerwasia*, which however is possible only if the type of the latter can be found and studied. The differences between the intra-epidermal and superstomal forms of *Mainsia* are so slight that it is inadvisable to segregate them under separate genera.

Arthur, J. C. (1934). Manual of Rusts. p. 85

Arthur, J. C. and Cummins, G. B. (1936). *Philip. J. Sci.* **61** : 466-467

Cummins, G. B. (1943). *Bull Torrey bot. Cl.* **70** : 71-73

Fig. 63. Maravalia

70 **MARAVALIA** Arthur in *Bot. Gaz.* **73**, p. 60, 1922 Fig. 63

Syn. *Argomycetella* Sydow in *Ann. mycol.* Berl. **20** : 124, 1922

Scopellopsis Ramakrishnan, T. S. & K. in *Proc. Indian Acad. Sci.* **26** : 59-63, 1947

Pycnia subepidermal, flask-shaped or conoid, with ostiolar paraphyses. Aecia subepidermal, flat, peridiate ; aeciospores verrucuose, catenulate. Uredia subepidermal ; urediospores echinulate, pedicellate. Telia subepidermal, erumpent ; teliospores 1-celled, ovate-ellipsoid to clavate, pedicellate, cylindric with thin walls, hyaline ; spores germinating immediately at maturity by the prolongation of the spore-apex ; promycelium external and 4-celled.

TYPE SPECIES : *Maravalia pallida* Arthur and Thaxt. on *Pithecolobium latifolium* (Leguminosae)

DISTRIBUTION : Central and South America, India, Philippines (8 species)

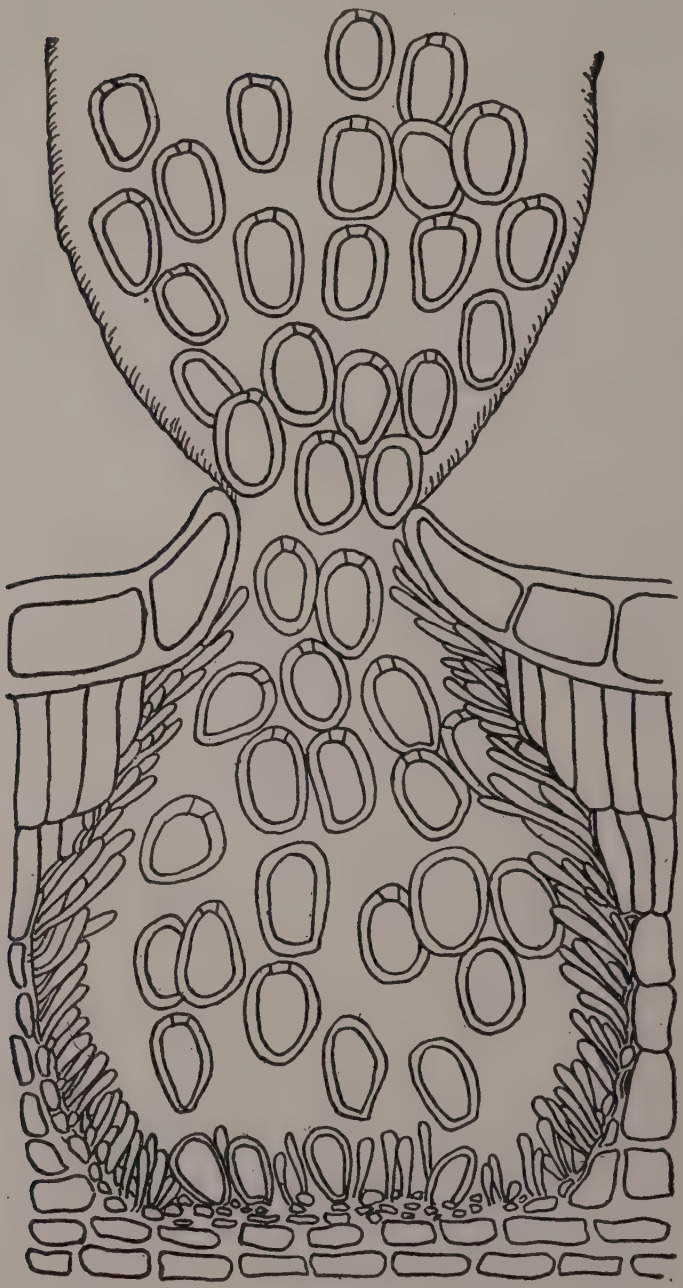


Fig. 64. Masseeella

NOTES : Arthur based the genus *Maravalia* on the type of life-cycle and concluded that it was apparently a short-cycled *Spirechina*. But Jackson (1931) showed that the type of *Spirechina* is a species of *Kuehneola* and substituted the generic name *Mainsia* for the other species on *Rubus* and described as *Spirechina*, but with 1-celled, hyaline teliospores. The intraepidermal nature of the sori in *Mainsia* separates it from *Maravalia*. An account of the genus and species of *Maravalia* is given by Mains (1939). He pointed out that *Argomycetella* described by Sydow (1922) is synonymous with *Maravalia* on account of priority. Dietel (1928) recognises both *Maravalia* and *Argomycetella* but a comparative study indicates that they are cogeneric. The teliospores have no germ pores but germinate by the prolongation of the spore-apex, a character which differentiates them from *Poliotelium* Sydow.

The genus *Scopellopsis* described by Ramakrishnan T. S. and K. (1947) has been shown by Thirumalachar and Cummins (1949) to be synonymous with *Maravalia*. They state that the clustered nature of the spores on the sporogenous basae cells represents only one mode of spore development and has no generic significance.

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 66

Jackson, H. S. (1931). *Mycologia* **23** : 106-107

Mains, E. B. (1939). *Bull Torrey bot. Cl.* **66** : 173-179

Thirumalachar, M. J. and Cummins, G. B. (1949). *Mycologia*

71 **MASSEEELLA** Dietel in *Ber. dtsch. bot. Ges.* **13**, p. 332, 1895 Fig. 64

Pycnia amphigenous, subcuticular, conoid, without conspicuous ostiolar paraphyes. Aecia cupulate, peridiate ; peridium evanescent, or absent in some cases, but usually well developed and reflexed. Uredia subepidermal, minute, erumpent and pulverulent ; urediospores ovate-ellipsoid, with distinct germ pores. Telia mostly epiphyllous, in solitary or aggregated, curly, hair-like spore-columns, chestnut brown, produced in succession from the hymenium lining the sorus, and emerging out embedded in a gelatinous matrix secreted by slime producing hyphae on the sides ; mucilage swelling in water and hardening when dry ; spores germinating by a 4-celled external promycelium.

TYPE SPECIES : *Masseeella capparidis* (Hobson) Dietel on *Flueggea virosa* (Euphorbiaceae). Host misdetermined by Hobson as *Capparis* sp.

DISTRIBUTION : India, Philippines, Burma

NOTES : The genus was established by Dietel for a rust collected by Hobson in Belgaum, India, the host being cited as *Capparis* sp. Sydow and Petrak (1928) reported *Masseeella flueggeae* Sydow from the Philippines on *Flueggea virosa* having identical spore measurements as *Masseeella capparidis*. A comparative study of the type of Mundkur and Thirumalachar (1946) indicated that the host of *Masseeella capparidis* was also *Flueggea* sp. and consequently reduced *Masseeella flueggeae* to synonymy by *Masseeella capparidis*. Pycnia and aecia were first reported by Cummins (1937). Thirumalachar (1943) observed them in *Masseeella breyniae* and *Masseeella narasimhanii*. The aecia are well developed in the former and evanescent or absent in the latter.

The character of the telia distinguishes *Masseeella* from any known genus. The spore-tendrils resemble those of *Cronartium* only superficially, but in their formation the spores are held together not by mutual compression and union as in *Cronartium* but by a gelatinous matrix.

Cummins, G. B. (1937). *Ann. mycol. Berl.* **35** : 103

Dietel, P. (1928) Die natürlichen Pflanzenfamilien **6** : 93

Mundkur, B. B. and Thirumalachar M. J. (1946). *Mycol. Pap. Imp. Mycol. Inst.* **16** : 11-12

Sydow, H. and Petrak, F. (1928). *Ann. mycol. Berl.* **26** : 424

Thirumalachar, M. J. (1943a). *New Phytologist* **42** : 45-89

Thirumalachar M. J. (1943b). *Proc. Indian Acad. Sci.* **18** : 36-40

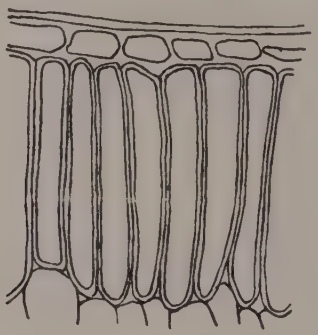


Fig. 65. Melampsora

72 **MELAMPSORA** Castagne in *Observ. Mycol.* II, p. 18, 1843 Fig. 65

Syn. *Necium* Arthur in N. Amer. Fl. **7** : 114, 1907

Physonema Lév. in *Ann. Sci. nat. Bot.* 3rd. Ser. VIII, p. 374, 1847

Podocystis Fr. *Summa Veget. Scand.* II, p. 517, 1849

Podosporium Lév. in *Ann. Sci. nat. Bot.* 3rd Ser. VIII p. 374, 1847

Pycnia subcuticular, rarely subepidermal, conoid. Aecia when present with rudimentary peridium or none, without paraphyses, orange yellow ; aeciospores in chains, globoid and verruculose. Uredia subepidermal, erumpent, pulverulent; urediospores associated with capitate paraphyses, pedicellate. Telia subepidermal or subcuticular, crustaceous, compacted laterally into firm layers, often confluent, at first pale, later brownish-black, non-erumpent ; teliospores in a single layer, adhering laterally, 1-celled, prismatic ; walls coloured ; promycelium external, 4-celled.

TYPE SPECIES : *Melampsora euphorbiae* (Schubert) Cast. on *Euphorbia cyparissias* (Euphorbiaceae)

DISTRIBUTION : Wide spread (over 80 species)

NOTES : The genus includes both heteroecious and autoecious rusts. In the heteroecious species the telia with the exception of a single species usually occur on woody dicots such as *Saxifraga*, *Ribes*, *Corydalis*, *Mercuralis* and others and the aecia on conifers like *Larix*, *Tsuga*, *Abies* and *Pseudotsuga*.

Pycnia and telia in some species of *Melampsora* show variation in position in relation to the epidermis. They are both subcuticular and subepidermal in origin. These features which are employed as important distinguishing characters in rust

taxonomy show variation in *Melampsora*. Thirumalachar and Cummins (1949) in discussing the importance of subepidermal or subcuticular condition of pycnia in rust taxonomy stated that next to telia, the pycnia are very conservative to variation and offer a good basis for diagnosis. The only exceptions cited were those of *Ravenelia* and *Melampsora*. These two genera show a range of variation from subcuticular to sub-epidermal condition Especially in *Ravenelia* the teliospores may be 1-celled (*Haploravenelia*) or 2-celled (*Pleoravenelia*) but still the species are placed under one genus taking a broad view of the variation and above all to maintain a well established procedure among the workers of rust fungi.

When the species of *Melampsora*, so far known, are considered, the following facts become manifest :

1. Species having part of their life-cyle on the conifers show subcuticular pycnia ;
2. Species having their complete life-cyle on dicots alone have subepidermal pycnia.

Former group may include *Melampsora farlowi* (Arth.) J. J. Davis on *Tsuga canadensis*, formerly placed under a separate genus *Necium* by Arthur (1907), of which pycnial stage has not yet been found. There are differences enough to separate species with subcuticular pycnia into a distinct genus but as already stated, it is proper to take a more conservative view, as in *Ravenelia*, and desist from doing so. However for the sake of convenience, two subgenera may be recognised to indicate these differences :

(a) *Eumelampsora* for species with subepidermal pycnia, including autoecious species ; and

(b) *Heteromelampsora* for species with subcuticular pycnia, being heteroecious rusts with pycnial and aecial stages on conifers.

Arthur, J. C. (1924). N. Amer. Fl. **7** : 663
Arthur, J. C. (1934). Manual of Rusts. pp. 50-51
Sydow, H. & P. (1915). Monogr. Ured. III : 334
Thirumalachar, M. J. and Cummins G. B. (1949) *Mycologia*, **41** : 417-422

73 **MELAMPSORELLA** Schroeter in *Hedwigia* **13**, p. 85, 1874 Fig. 66

Pycnia subcuticular or substomal, hemispherical, without conspicuous ostiolar filaments. Aecia subepidermal, erumpent, slightly cylindrical, bullate ; peridium colourless, with thin-walled cells ; aeciospores orange-yellow, globose to ellipsoid, verrucose with a hyaline membrane. Uredia subepidermal, erumpent, bordered by a thin delicate peridium, opening by a central pore ; urediospores ellipsoid, to obovate, with bright-orange contents ; wall thin and sparsely echinulate. Telia hypophyllous, forming large whitish or pinkish areas, intra-epidermal, non-erumpent ; teliospores developed inside epidermal cells, globose to ellipsoid, usually 1-celled ; epispore thin smooth and colourless ; teliospores germinating at maturity by the formation of 4-celled external promycelium bearing ovate to globose, hyaline sporidia.

TYPE SPECIES : *Melampsorella caryophyllacearum* Schroeter on *Stellaria media* (Caryophyllaceae)

DISTRIBUTION : Europe, North America and North Asia (2 species)

NOTES : A heteroecious genus with pycnia and aecia on conifers (*Abies* and *Picea*) and uredia and telia on members of Caryophyllaceae and Boraginaceae. The rust causes large witches' brooms on *Abies* and *Picea*. Pady (1941) who made detailed studies noted that the pycnia formed on *Abies* are subcuticular and those formed on *Picea* substomal. He (1940) first misconstrued the latter as subepidermal but

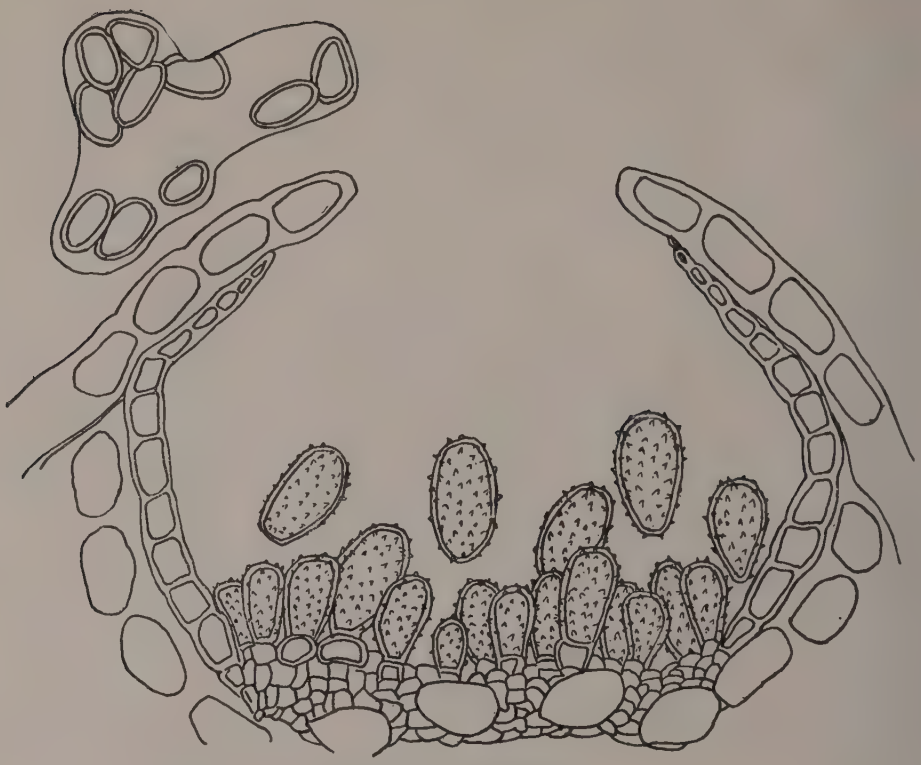


Fig. 66. Melampsorella

later (1941) showed that they are not subepidermal in the accepted sense of the word since no epidermal cells are ever formed above them. He further stated that sub-cuticular interpretation would be the only alternative. The development and germination of the teliospores are similar to those of the other members of the Pucciniastreae possessing intra-epidermal telia. Species of *Hyalopsora*, *Milesina*, *Thekopsora* and *Calyptopsora* also possess intra-epidermal teliospores but they are multicellular by vertical septation in contrast to *Melampsorella* where they are 1-celled.

Arthur, J. C. (1907). N. Amer. Fl. **7** : 111

Arthur, J. C. (1934). Manual of Rusts. p. 20-21

Arthur, J. C. and Kern. F. D. (1907). *Bull. Torrey Bot. Cl.* **33** : 403-438

Bubak, F. (1904). *Zbl. Bakt.* II, Abt. **12**, p. 422-425

Dietel, P. (1928). Die naütrlichen Pflanzenfamilien **6** : 40

Hunter, L. M. (1927). *Bot. Gaz.* **83** : 1-22

Magnus, P. (1899). *Ber. dtsch. bot. Ges.* **17** : 337-343

Pady, S. M. (1940). *Trans. Kansas Acad. Sci.* **43** : 147-153

Pady, S. M. (1941). *Trans. Kansas Acad. Sci.* **44** : 190-201

Pady, S. M. (1946). *Mycologia* **38** : 477-499

Sydow, H. and P. (1915). Monogr. Ured. III : 432

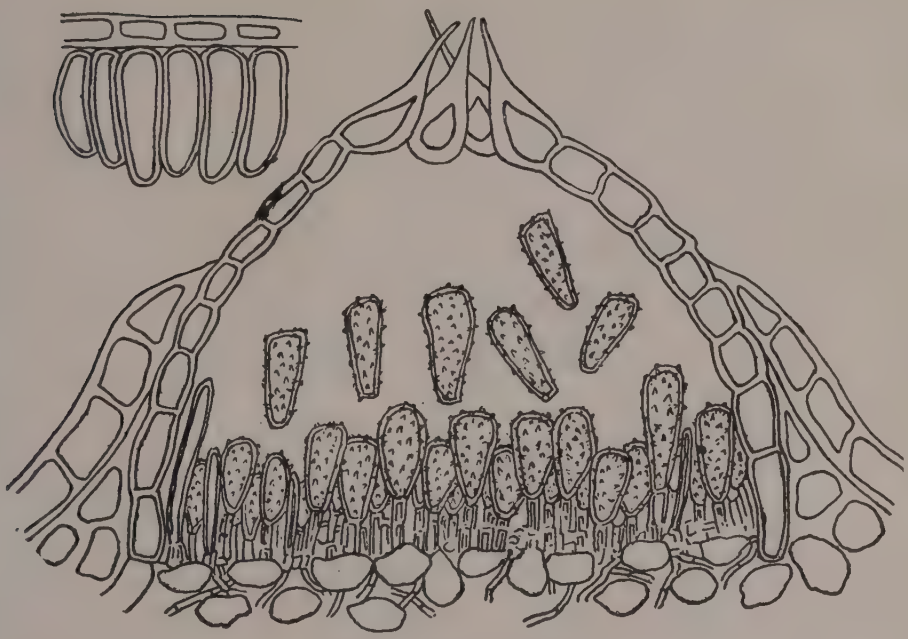


Fig. 67. Melampsoridium

74 **MELAMPSORIDIUM** Klebahn in *Z. Pflankr.* **9**, p. 31, 1899 Fig. 67

Pycnia sub-cuticular, without conspicuous ostiolar paraphyses. Aecia sub-epidermal, erumpent, irregularly dehiscent, with well developed peridia ; aeciospores ovate-ellipsoid, with orange-yellow contents. Uredia subepidermal, erumpent, bullate, opening by a pore surrounded by ostiolar cells ; sorus lined with peridium ; urediospores elongate-ellipsoid, with orange-yellow contents. Telia sub-epidermal, non-erumpent forming *Melampsora*-like crusts ; teliospores 1-celled, cylindric, laterally adhering with one another ; walls coloured, thin.

TYPE SPECIES : *Melampsoridium betulinum* (Pers.) Kleb. on *Betula alba* (Betulaceae)

DISTRIBUTION : North America, Europe, Northern Asia (3 species)

NOTES : The genus includes heteroecious species with pycnial and aecial stages on the conifer, *Larix*, and uredial and telial stages on the dictos. The genus was established for species with telia like those of *Melampsora* but possessing peridiate aecia and uredia. The uredia open out by a pore which is bordered by ostiolar cells, a characteristic of *Pucciniastrum* also. While the aecial stages resemble those of *Pucciniastrum*, the telia are like those of *Melampsora*.

Arthur, J. C. (1907). North Amer. Fl. **7** : 110

Arthur, J. C. (1934). Manual of Rusts. p. 22-23

Dietel, P. (1928). Die naturlichen Pflanzenfamilien **6** : 41

Sydow, H. & P. (1915) Monogr. Ured. III : 423

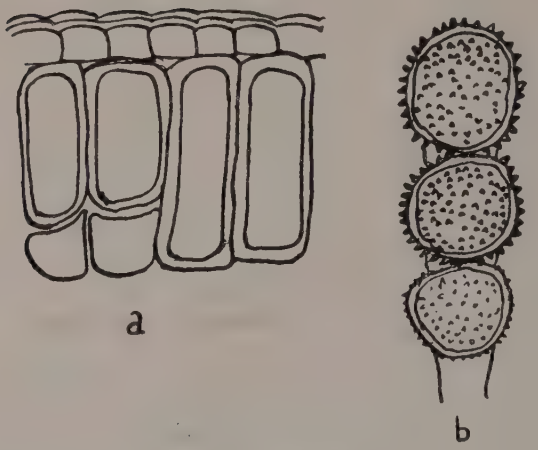


Fig. 68. Mesospora

75 **MESOSPORA** Dietel in *Ann. Mycol.* **20**, p. 30, 1922 Fig. 68

Pycnia and aecia unknown. Uredia subepidermal, erumpent, caemoid, without peridium or paraphyses ; urediospores produced in short chains, ellipsoid and verruculose. Telia in *Melampsora*-like crusts, sub-epidermal, non-erumpent ; teliospores 1-celled, sessile, prismatic with coloured walls.

TYPE SPECIES : *Mesopsora hypericorum* (DC.) Dietel on *Hypericum* sp. (Hypericaceae)

DISTRIBUTION : Europe and North Africa (1 species)

NOTES : The rust was described earlier under the name *Melampsora hypericorum* (DC.) Winter since the telial stage is indistinguishable from that of *Melampsora*. The status accorded to the genus depends on the interpretation of the nature of the caemoid sorus accompanying the telia. According to Fischer (1904), Doidge (1926) and other earlier investigators these are caemoid aecia and the rust is placed by them in *Melampsora*. As against this Dietel (1922) considers the caeoma accompanying the telia to be of the nature of uredia which would characterise the new genus *Mesopsora*. Such a type of caemoid uredium with spores developing in chains is characteristic of *Coleosporium* and *Chrysomysa*. The lack of pycnia with the caemoid sorus in *Mesopsora* is a strong point in favour of considering it as a uredium. Dietel thinks that the pycnial and aecial stages may be found on coniferous hosts such as *Abies* and *Larix* in which case *Mesopsora* would show characters intermediate between *Melampsora* and *Coleosporium*.

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 41

Doidge, E. M. (1926). *Bothalia* **2** : 158

Fischer, Ed. (1904). *Beitr. Kryptogamenfl. Schweiz.* **2** : 506-507

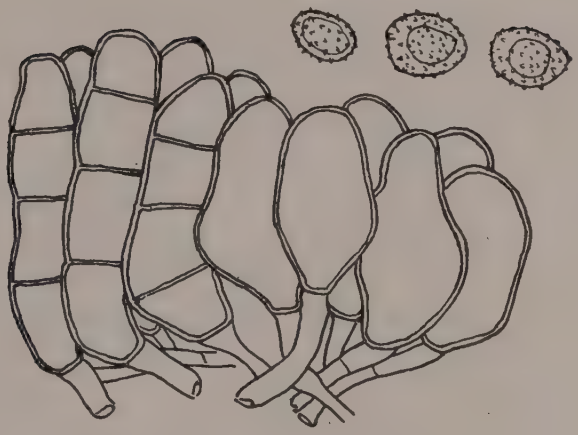


Fig. 69. Mikronegeria

76 **MIKRONEGERIA** Dietel in Engler's *Bot. Jb.* **37**, p. 16, 1899 Fig. 69

Pycnia and aecia unknown. Uredia subepidermal; urediospores pedicellate, developed on sporogenous basal cells. Telia subepidermal, small, waxy; teliospores 1-celled, sessile, ellipsoidal at first, later cylindric, free amongst themselves and not laterally coalescent; germinating at maturity by a 4-celled internal promycelium.

TYPE SPECIES: *Mikronegeria fagi* Dietel on *Fagus procera* (Fagaceae)

DISTRIBUTION: Chile, South America (1 species)

NOTES: The urediospores of the rust occur in clusters on sporogenous basal cells which are laterally free. Though this character has no diagnostic value, it serves to differentiate the genus from closely related *Coleosporium* which shows a somewhat similar type of telium but has caemoid uredia with catenulate urediospores. Further, the teliospores are laterally free and do not show any coalescence as in *Coleosporium*.

Dietel, P. (1926). *Ann. Mycol.* **24**: 131-132

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **8**: 46

Sydow, H. & P. (1915). Monogr. Ured. III: 672-573

77 **MILESINA** Magnus in *Ber. Dtsch Bot. Ges.* **27**, p. 325, 1909 Fig. 70

Syn. *Milesia* White in *Scot. Naturalist* **4**, p. 162, 1877

Pycnia subcuticular, lenticular, without conspicuous ostiolar paraphyses. Aecia hypophyllous, minute, subepidermal, cylindric, colourless, ruptured at apex, with firm, colourless peridia; peridial cells minute, irregularly polyogonal; aeciospores catenulate, globose, subglobose or ellipsoidal, hyaline, tuberculate. Uredia mostly hypophyllous, subepidermal, with definite peridium, opening out by a narrow pore or slit; urediospores white in mass, obscurely pedicellate, globoid, obovioid or lanceolate with colourless cell contents and colourless wall, echinulate, verruculose or smooth with indistinct germ pores. Telia imperfectly formed, intra-epidermal; teliospores few to many-celled by vertical septations forming a crust of one layer thickness; wall thin, colourless, smooth with one pore in upper wall of each cell.

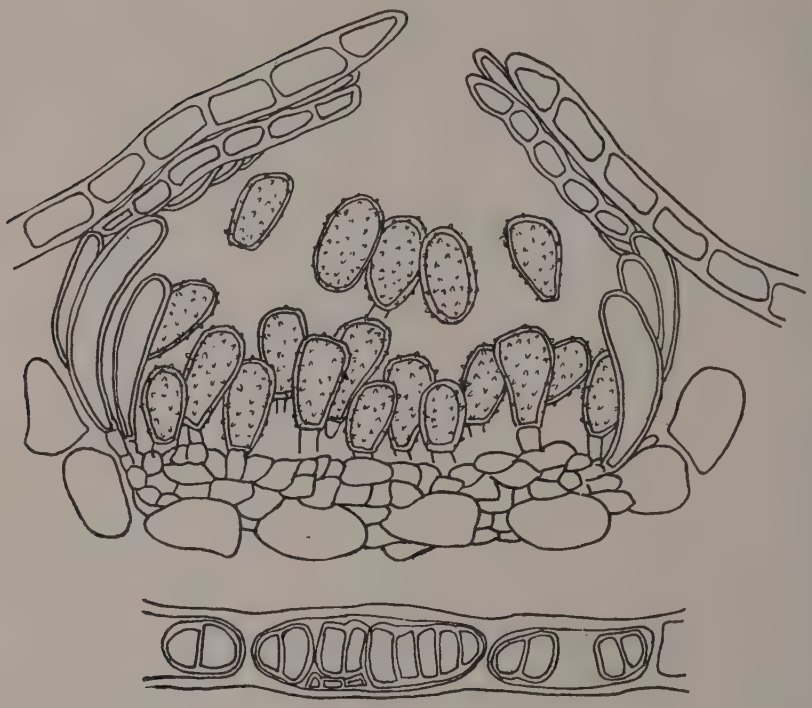


Fig. 70. Milesina

TYPE SPECIES : *Milesina kriegeriana* Magnus on *Dryopteris* sp. (Polypodiaceae) is designated as the type by Hiratsuka

DISTRIBUTION : Europe, North America, Japan (50 species)

NOTES : The genus was first described by White in 1877 under the name *Milesia* based on the uredial stage alone, on *Polypodium vulgare*. Twenty-six years later Sydow discovered the telial stage but described it erroneously as *Melampsorella dieteliana*. Magnus established the genus *Milesina* on the telial stage and reduced *Milesia* White to synonymy. This is in strict conformity with the International Rules of Botanical Nomenclature and is accepted by Dietel, Sydow, Klebahn, Hiratsuka, Grove, Cunningham and others though Arthur and Faull disagree and maintain *Milesia*. Faull (1932) gives a detailed discussive account about nomenclature. The characters of the uredial stage while being important in rust taxonomy can be accorded only secondary status in relation to the telial characters. The Arthurian concept of recognising the uredial stage as constituting the 'perfect state' of the rust on account of the sporophytic or diploid state is untenable since recent studies have revealed that in rare cases pycnia and aecia may also be in a dicaryotic phase.

The genus includes heteroecious species with pycnial and aecial stages of *Abies* and uredial and telial stages on Ferns. The first account of the heteroecious nature was reported by Klebhan (1916).

The pycnia are subcuticular in all the species excepting the reported subepidermal condition in *Milesina polypodophilla* with aecial stage on *Abies balsameae*. If the pycnia are subepidermal, this is a condition reminiscent of *Hyalopsora*. Further studies may reveal a similar situation as in *Melampsorella* described by Pady (1941) which has already been referred to. The investigations of Kamei, Faull and others have shown that there are more than one host species for the aecial stage for the same rust species. In *Milesina marginalis*, Faull (1932) reports that the pycnia are covered by a cuticle and the intermediate layer of external epidermal wall. This condition is exactly similar to that described by Pady for *Melampsorella cerastii* on *Picea*, where he discusses the substomal or modified subcuticular pycnia conditioned by the anatomy of the pine needle.

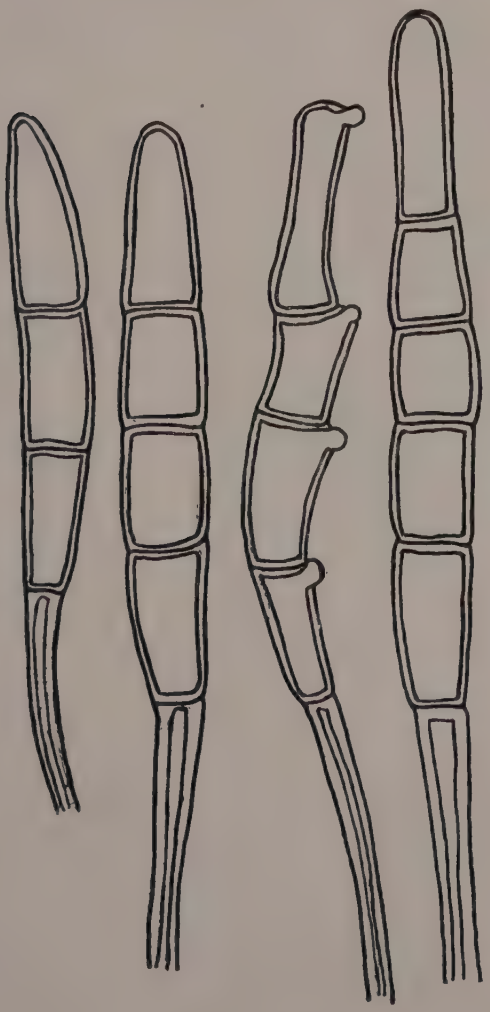


Fig. 71. Mimema

Milesina is distinguished from *Uredinopsis* by its intra-epidermal telia and *Hyalopsora* by its hyaline urediospores without distinct germ pores and subcuticular pycnia. As against this, the urediospores in *Hyalopsora* have coloured cell contents and possess distinct equatorial germ pores. Further the pycnia are subepidermal.

Arthur, J. C. (1925). North Amer. Fl. **7** : 685-687

Arthur, J. C. (1934). Manual of Rusts, pp. 5-9

Dietel, P. (1928). Die naturlichen Pflanzenfamilien **6** : 38-39

Faull, J. H. (1932). *Contr. Arnold Arbor.* II, 138 pp

Faull, J. H. (1934). *J. Arnold Arbor.* **15** : 50-85

Hiratsuka, N. (1936). *Mem. Tottari Agric. Coll.* IV, p. 374

Kamei, S. (1930). *Trans. Sapporo Nat. His. Soc.* **12** : 27-33

Klebahn, H. (1916). *Ztschr. Pflanzenkr.* **26** : 257-277

Pady, S. M. (1941). *Trans. Kansas Acad. Sci.* **44** : 190-201

Sydow, H. & P. (1915). Monogr. Ured. III : 473

78 **MIMEMA** Jackson in *Mycologia* 23, p. 339, 1931 Fig. 71

Pycnia and aecia unknown. Uredia subepidermal, erumpent, paraphysate, paraphyses marginal and incurved, arising from the sides and mouth of the sorus and developed on a hyphoid base; urediospores pedicellate, with indistinct germ

pores. Telia developing within the uredia ; teliospores cylindric to fusiform, 3-5-celled, pedicellate, subhyaline, with a single germ pore in each cell ; germinating immediately at maturity.

TYPE SPECIES : *Mimema holwayi* Jackson on *Cassia versicolor* (Leguminosae)
DISTRIBUTION : Bolivia, South America (1 species)

NOTES : In describing the genus, Jackson stated that it closely parallels *Hamaspora* in characters but develops on Leguminosae instead of Rosaceae. For the benefit of those who failed to recognise the genus which he considered was based on host group, he also proposed the alternate name of *Hamaspora holwayi*.

As already discussed under *Hamaspora*, a careful examination of the uredia has revealed characteristic differences. The development of incurved paraphyses from hyphoid peridial-like base is comparable to the structure of the sorus found in *Cerotelium*. This separates the genus from *Hamaspora* which possess uredia of the type found in *Phragmidium*.

Jackson also pointed out the close similarity between the teliospores of *Alloopuccinia* (*Sorataea*) and *Mimema*, which differ only as regards the number of cells in the teliospores. A careful examination of the uredium in *Sorataea amiciae*, the type of the genus, has shown, however, that its mode of development is similar to that found in *Crossopsora*, *Olivea* and others and thus quite different from *Mimema*.

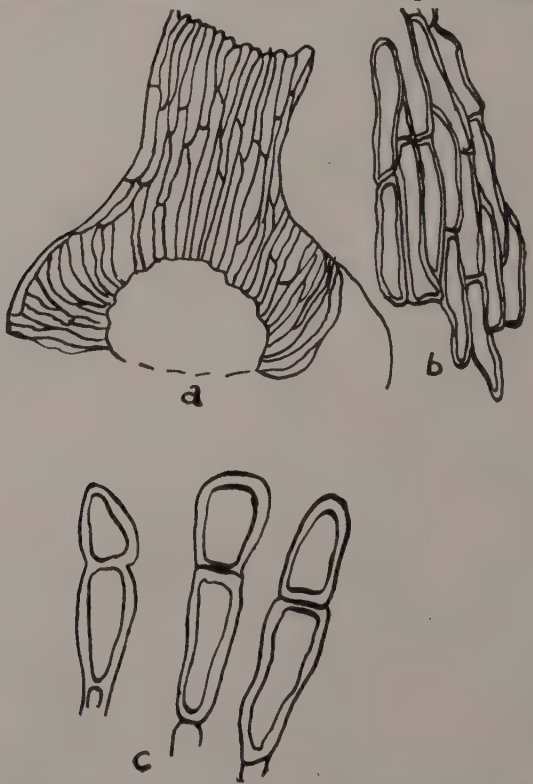


Fig. 72. Miyagia. a. Peridium. b. Uredia. c. Teliospores

79. **MIYAGIA** Miyabe in *Ann. Mycol.* 11, p. 107, 1913 Fig. 72

Pycnia subepidermal, flask-shaped, with ostiolar paraphyses. Aecia subepidermal, cupulate, with well developed peridia ; aeciospores developed in chains. Uredia subepidermal, enclosed by a well developed persistent peridium formed of elongated, slightly brown, closely connected cells resembling paraphyses, and opening out by a central pore ; urediospores pedicellate, globose or ovate. Telia developing within the uredia or separately, subepidermal ; teliospores *Puccinia*-like, 2-celled, pedicellate.

TYPE SPECIES : *Miyagia anaphalidis* Miyabe on *Anaphalis margaretacea* (Compositae)

DISTRIBUTION : Japan (1 species)

NOTES : In the original description of the genus pycnia were simply stated to be globose without any mention of their relative position regarding the epidermis. A study of an authentic specimen obtained from Mus. Bot. Stockholm revealed that the pycnia are subepidermal with well developed ostiolar paraphyses.

The presence of a stockade of peridium composed of laterally coalescent palisade-like cells in the uredia is the distinguishing character separating it from *Puccinia*. Dietel at first considered that it may be synonymous with *Puccinia*, resembling species like *Puccinia sonchi* but later (1928) recognised it as a valid genus. *Corbulopsora* Cummins also recorded on Compositae possesses similar type of peridial structure for the uredia and telia but the teliospores are 1-celled (Cummins, 1940) as against 2-celled ones in *Miyagia*.

Cummins, G. B. (1940). *Mycologia* **32** *:* 364-365
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** *:* 91

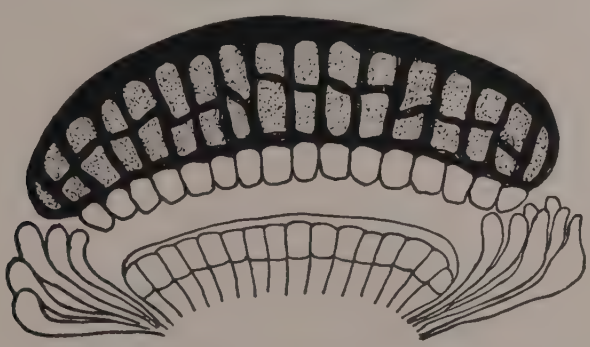


Fig. 73. Nothoravenelia

80. **NOTHORAVENELIA** Dietel in *Ann. Mycol.* 8, p. 310, 1910 emend. Fig. 73

Pycnia and aecia unknown. Uredia solitary, covered by incurved club-shaped paraphyses. Telial initials subepidermal at first, later superstomal, sori being formed above the epidermis, thus appearing superficial ; paraphysate ; paraphyses marginal and incurved ; teliospores formed in catenations from clavate basal cells, 2 to 3 spores in a chain, firmly united with one another by coalescence to form a compact pulvinate head ; reddish brown, thick-walled and smooth ; entire head separating at maturity from basal cells by an intercalary sterile layer of abstrictor cells which rupture and remain attached to the base of the telial head ; occasionally more than one head formed from each sorus successively.

TYPE SPECIES : *Nothoravenelia japonica* Dietel on *Securinega fluggeoides* (Euphorbiaceae)

DISTRIBUTION : Japan (1 species)

NOTES : In describing this genus Dietel made no mention of the subcuticular or subepidermal nature of the sori. In a restudy of the authentic material, the senior author has found interesting features not recorded before. The observations refer only to telia which were alone present in the material. The telial sorus is organised in the same manner as in *Olivea*, the telial initials being at first subepidermal and later superstomal and superficial. From a palisade layer of basal cells chains of 2 to 3 spores are formed in basipetal succession. These form a compact pulvinate head of reddish-brown spores and are separated from the basal spore mother-cells by an intercalary sterile layer of cells which are homologous to the spores in development and function as abstrictors. As the heads mature, there is a distinct cleavage separating the sterile abstrictor cells and the basal cells. The entire telial head separates away carrying with it a fringe of the hyaline abstrictor cells. Only in a few cases has the development of more than one telial head within the same sorus been noticed.

In his description Dietel has stated that the teliospores are 2-celled at the centre, those at the edge remaining one-celled. But a careful study has now revealed that they are 1-celled and formed in chains up to 3 spores, as in *Angiopsora* where the teliospores were once mistaken for 2-celled spores.

The hyaline layer of abstrictor cells have been termed cysts by Dietel since they are persistent and borne on the telial heads. However they are not comparable to the cysts found in *Ravenelia* as they do not swell in water but only take part in the abstriction of the telial heads from the hymenial layers. There is some relationship with *Dasturella* which also shows compact telial heads which, however remain persistent and attached to the sorus.

Dietel, P. (1928). Die naturlichen Pflanzenfamilien **6** : 73
Sydow, H. & P. (1915). Monogr. Ured. III: 311-312
Thirumalachar, M. J. (1950) .. .. (in Press)

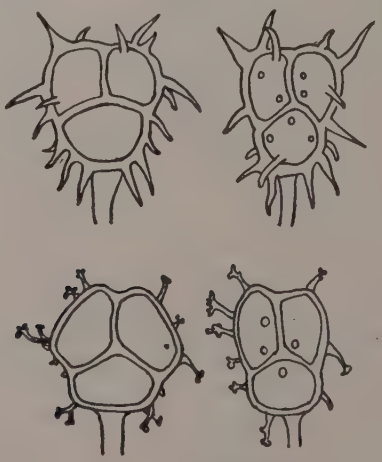


Fig. 74. Nyssopsora

81. **NYSSOPSORA** Arthur in *Rèsult. Sci. Congr. Bot. Vienna*, p. 342, 1906 Fig. 74

Syn. *Oplophora* Sydow in *Ann. Mycol.* **19** : 170, 1921

Pycnia and aecia unknown. Uredia subepidermal, aparaphysate ; urediospores developed singly and without distinct germ pores. Telia subepidermal, naked, black ; teliospores pedicellate, 3-celled as in *Triphragmium*, the odd spore being basal, opaque ; walls deeply coloured, covered with simple or glochidiate spines and with two germ pores in each cell.

TYPE SPECIES : *Nyssopsora echinata* (Link) Arthur on *Meum athamanticum* (Umbelliferae).

DISTRIBUTION : Europe, North America, Japan and India (8 species).

NOTES : The present understanding of the genus is due to Tranzschel (1925) who revised *Triphragmium*. He divided *Triphrgamium* into two sections, the first having teliospores with one germ pore in each cell, *Triphragmium* Link, and the second section having teliospores with two germ pores in each cell. The latter was again subdivided into two subdivisions, one of them, *Triphragmiopsis* Naumov with light brown teliospores and *Nyssopsora* Arthur with dark or very nearly opaque teliospores. The genus includes both short and long cycled forms ; the latter was placed by Sydow under a separate genus *Oplophora* which, however, is now considered as a synonym.

Arthur considered the uredia as uredinoid aecia and that real uredia are absent in the life cycle. Since pycnia do not accompany these sori, it is more in keeping with facts to consider them as uredia.

Sydow, H. & P. (1915). Monogr. Ured. III : 2
Tranzschel, W. (1925). J. Soc. Bot. Russis, vii, 123-132

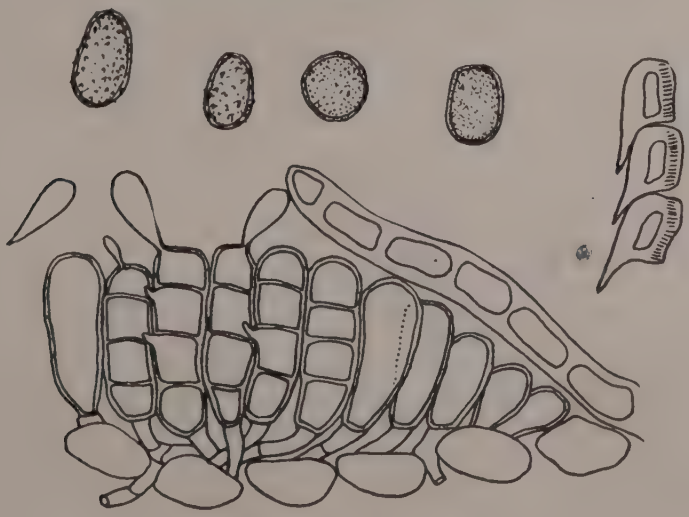


Fig. 75. Ochropsora

82. **OCHROPSORA** Dietel in *Ber. Dtsch. Bot. Ges.* **13**, p. 410, 1895 Fig. 75

Pycnia subcuticular, pallid, conoid. Aecia cupulate, subepidermal, with well developed peridia ; aeciospores catenulate, globoid, verruculose. Uredia subepidermal, surrounded by numerous, thin, hyaline paraphyses, coalescing at the base and free at apex, urediospores single, pedicellate, without distinct germ pores. Telia subepidermal, minute, pale, waxy ; teliospores cylindric, combined into palisade-like crusts, sessile, thin-walled, germinating at maturity by an internal 4-celled promycelium, each producing a sessile spindle-shaped sporidium.

TYPE SPECIES : *Ochropsora sorbi* (Oud.) Dietel on *Sorbus* sp

DISTRIBUTION : Europe, Japan, India (3 species)

NOTES : Heteroecious rusts with uredia and telia on *Sorbus*, *Pyrus* and *Aruncus* and pycnia and aecia on *Anemone* spp., such as *Anemone nemorosa*, *Anemone trifolia*. The Sydows (1915) state that the sporidia are not sessile but possess short sterigmata. It is not certain whether *Ochropsora nambuana* (Henn.) Dietel and *Ochropsora kraunhiae* Dietel on *Eleagnus* sp. and *Kraunhia* sp. respectively should be included here.

Dietel, P. (1928). Die naturlichen Pflanzenfamilien **6** : 56

Sydow, H. & P. (1915). Monogr. Ured. III, p. 660-661

Tranzschel, W. (1903). *Zbl. Bkt.* II, Abt. **11** : 106

Fig. 76. Olivea Teliospore cluster, germinating teliospore. 3 teliospores empty. Section through a telium

83. **OLIVEA** Arthur in *Mycologia*, **9**, p. 60, 1917 Fig. 76

Pycnia subcuticular, conoid, without conspicuous ostiolar filaments. Aecia subepidermal, deeply immersed, without peridium, opening out by a narrow mouth ; aeciospores catenulate, with intercalary cells, angularly globoid. Uredia subepidermal at first, later superstomal, forming sori above the epidermis and thus appearing superficial ; surrounded by strongly incurved paraphyses, coalescent at the base and forming nest-like structure ; urediospores pedicellate, ovate-oblong with indistinct germ-pores. Telia similar to uredia ; teliospores one-celled, clavlate-cylindric, sessile, colourless, with thin wall ; spores germinating atonce at maturity forming a 4-celled external promycelium bearing globular sporidia.

TYPE SPECIES : *Olivea capituliformis* (P. Henn.) Arthur on *Alchornea* sp. (Euphorbiaceae)

DISTRIBUTION : Brazil, British Honduras, Philippines, India. (4 sp.)

NOTES : The genus was established by Arthur for accomodating a rust on *Alchornea* sp. from Brazil. Arthur stated that the uredia and telia were subcuticular but Dietel (1928) contested this, and found them to be subepidermal. Mains (1940) and Thirumalachar (1949) noticed that the uredial and telial initials are at first subepidermal, grouped in the substomal space, and after emerging out of the stoma, form the sorus above the epidermis thus appearing superficial.

Arthur J. (1929). North Amer. Fl. **7** : 674
Dietel, P. (1928). Die naturlichen Pflanzenfamilien **6** : 54
Mains, E. B. (1940). *Bull Torrey Bot. Cl.* **67** : 705-709
Thirumalachar, M. J. (1949). *Current Science* **18** : 175-177

84. **PERIDERMIUM** Link in *Obs. Mycol.* II, p. 29, 1816

Pycnia subcuticular or subepidermal, indefinite, with short or no ostiolar paraphyses. Aecia subepidermal, erumpent, with well developed peridium, one or more than one cell in thickness ; aeciospores catenulate, globoid, ellipsoid or rarely lanceolate.

TYPE SPECIES : Based on a concept and not a type species

DISTRIBUTION : Wide spread (25 species)

NOTES : Under this form-genus are included various unconnected aecial stages of the rusts belonging to Melampsoraceae. They are distinguished from *Aecidium* primarily by their occurrence on gymnospermous hosts and secondly by their stronger peridial development. According to Bisby (1944) *Peridermium* was proposed as a subgenus by Link and it is not known who first raised it to generic rank.

Arthur, J. C. (1924). North Amer. Fl. **7** : 645
Arthur, J. C. (1934). Manual of Rusts. Lafayette, Indiana, 388-389
Arthur, J. C. and Kern, F. D. (1906). *Bull. Torrey Bot. Cl.* 33 : 403-438
Bisby, G. R. (1944). Mimeographed publication, Imp. Mycol. Inst. **2**, p. 15
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 96
Sydow, H. & P. (1924). Monogr. Ured. IV, p. 1

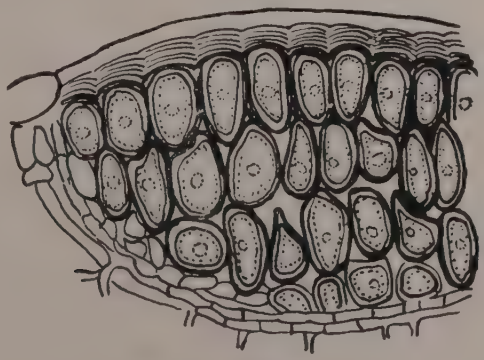


Fig. 77. Phakopsora

85. **PHAKOPSORA** Dietel in *Ber. Dtsch. Bot. Ges.* 13, p. 333, 1895 Fig. 77

Syn. *Physopella* Arthur in *Result. Sci. Congr. Internat. Bot. Wien*, 1905, p. 338, 1906

Pycnia and aecia unknown. Uredia subepidermal, erumpent, surrounded by encircling incurved paraphyses developing from hyphoid peridium and opening out by a narrow pore; urediospores developing singly, obovate-globoid or ellipsoid, pale yellow, with obscure germ pores. Telia subepidermal, non-erumpent, lenticular, black, teliospores one-celled, coloured chestnut brown or golden brown; spores formed in succession from the basal hymenium, younger spores wedging in between older ones and forming a compact crust and germinating after a rest period.

TYPE SPECIES: *Melampsora punctiformis* Dietel & Barclay on *Galium aparine* (Rubiaceae). *Phakopsora* combination was not actually made by Dietel

DISTRIBUTION: South America, East Indies, Japan, India (12 species)

NOTES: The genus was based on *Phakopsora punctiformis* collected on *Galium aparine* by Barclay in India. Dietel emphasized the fact that the teliospore crusts had spores which were not arranged in chains, which referred to younger spores between the older ones. As pointed out by Thirumalachar and Kern (1949) this fact has to be confirmed by an examination of the type which has not far been available to most of the workers.

Dietel made no mention of the occurrence of paraphyses or hyphoid peridium in the uredia and they were first pointed out by Magnus (1896). The uredial structure is distinct for the genus and Arthur transferred some rust species on *Vigna* and other leguminous hosts to *Phakopsora*, even though the telia had not been observed. This does not appear to be a correct procedure as the allied genera like *Angiopsora* etc., have also phakopsoroid uredia.

The genus *Physopella* was established by Arthur (1906) but reduced to synonymy of *Phakopsora* by him in 1925. Later (1934) he retained it as valid. In 1940 Sydow distributed in his *Fungi exotici exsiccati*, *Physopella burserae* Sydow thereby recognising the genus. Thirumalachar and Kern (1949) however discovered the telia and found it to be a *Phakopsora*. Recent studies have shown that most of the species of *Physopella* are really species of *Phakopsora* and Hiratsuka, Clements and Shear and others have reduced this genus to synonymy of *Phakopsora*.

An account of the differences between *Phakopsora* and the closely related genera *Bubakia* and *Angiopsora* which also possess non-erumpent lenticular crusts is already given under *Angiopsora*.

An aecial stage for the genus was reported by Mundkur (1943) in *Phakopsora stereospermi* which however is now known to be *Mehtamyces sterospermi*. The genus *Mehtamyces* itself is reduced to the synonymy of *Phragimidiella*.

Arthur, J. C. (1906). *Result. Sci. Congr. Internat. Bot. Wien.* 1905, p. 338

Arthur J. C. (1925). North Amer. Fl. **7**: 672

Arthur, J. C. Manual of Rusts, p. 60

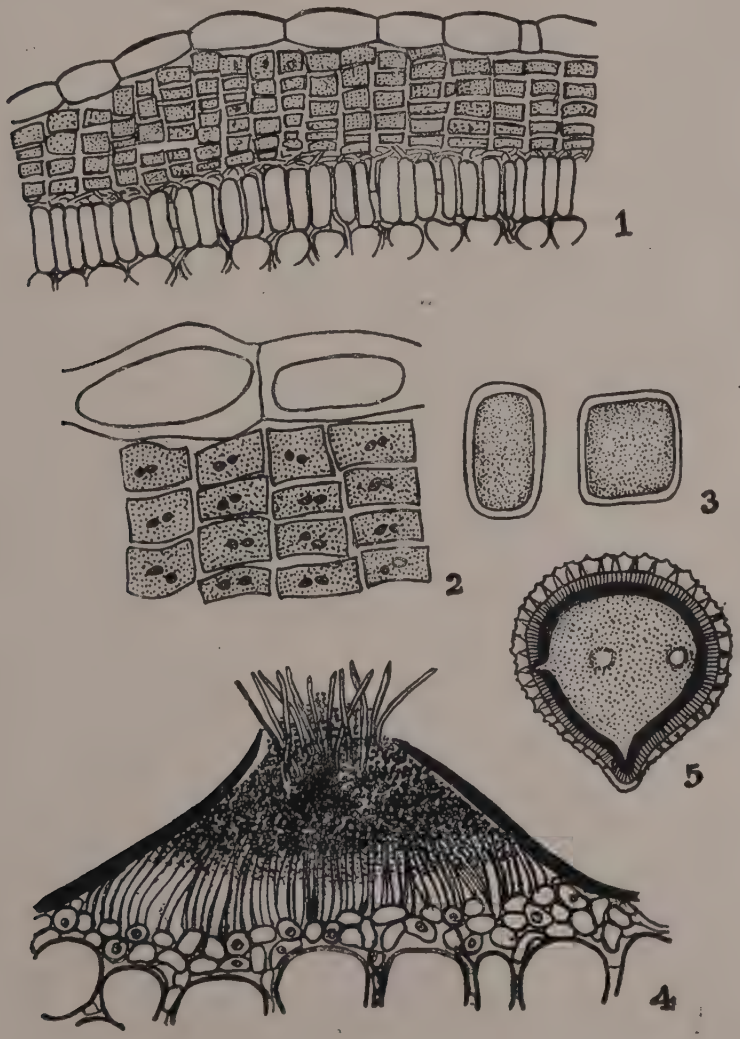
Clements and Shear, C. L. (1931). Genera of Fungi, p. 334

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 42

Hiratsuka, P. (1935). *Bot. Mag. Tokyo*, **49**: 781, 853

Hiratsuka, P. (1936). *Bot. Mag. Tokyo*, **50**: 2

Magnus, P. (1896). *Ber. Dtsch. Bot. Ges.* **14**: 129
Mundkur, B. B. (1943). *Mycologia*, **35** : 538 ; 545
Sydow, H. (1940). *Ann. Mycol.* **38**. 270
Sydow H. and P. (1915). Monogr. Ured. III : 406
Thirumalachar, M. J. and Kern, F. D. (1949). *Mycologia* 41 : 283, 290



Ffg. 78. Phragmidiella

86. **PHRAGMIDIELLA** P. Henn. in Engler's *Jahrb.* **38**, p. 194, 1905 Fig. 78

Syn. *Uredopeltis* P. Henn. *Ann. Mus. Congo Belge*. 2: 223, 1908
Mehtamyces Mundkur and Thirumalachar, *Mycologia*, 37 : 620, 1945 (?)
Santapauella Mundkur and Thirumalachar, *Mycologia*, 37 : 625, 1945

Pycnia subcuticular, applanate with ostiolar paraphyses. Aecia uredinoid, subcuticular, aparaphysate, erumpent, pulverulent ; aeciospores pedicellate, similar to urediospores that follow. Uredia subepidermal, erumpent, aparaphysate ; urediospores pedicellate. Telia in subepidermal crusts, erumpent, pulverulent at the apex ; teliospores one-celled, hyaline or pale-coloured, developed in chains from basal cells ; chains laterally coalescent to form a compact crust as in *Cerotelium* ; spores germinating without a rest period ; promycelium external, four-celled.

TYPE SPECIES : *Phragmidiella markhamiae* P. Henn. of *Markhamia sansibarensis* (Bignoniaceae)

DISTRIBUTION : East and Central Africa, India (3 species)

NOTES : The genus *Phragmidiella* was established by P. Hennings for a rust on *Markhamia sansibarensis* collected by Zimmermann in Central Africa. Only uredial and telial stages were described, uredia being subepidermal and aparaphysate. The telia were stated to be 3 to 4-septate, cylindrical and borne on pedicels. Hennings stated that the genus had characters intermediate between *Phragmidium* and *Kuheneola*, the former having multiseptate phragmospores and the latter possessing one-celled catenate teliospores. A detailed re-examination of authentic species of *Phragmidiella markhamiae* was made by Cummins and Gopalakrishna who have communicated to the authors a brief report for which kindness we are grateful to them. Pycnia and uredinoid aecia were observed for the rust, pycnia being subcuticular and applanate and the aecia subcuticular and aparaphysate. The teliospores were not phragmaspores but one-celled and catenate developed from basal cells which were mistaken for pedicels by Hennings. Arthur (1925) and the Sydows (1925) treated *Phragmidiella* as synonym of *Kuhneola*, while Clements and Shear (1931) and Dietel (1928) as synonym of *Cerotelium*. The same characters are duplicated in *Santapauella heterophragmae* described on *Heterophragma roxburghii* by Mundkur and Thirumalachar (1945), which is therefore now proposed as *Phragmidiella heterophrgmae* (Mundkur & Thirumalachar) comb. nov.

The genus *Uredopeltis* also described by P. Hennings on the same host genus *Markhamia* sp. from Belgian Congo should be placed under *Phragmidiella* since the telia and the teliospores in the latter are now shown to have the same structure. They are catenate and form a compact crust.

Comparison with *Mehtamyces stereospermi*, another rust on a bignoniaceous host, indicates somewhat close relationship with *Phragmidiella* though there are certain differences. *Mehtamyces stereospermi* was described by Mundkur and Thirumalachar (1945) as a hemiform with subepidermal aparaphysate uredia and with telia in subepideermal crusts which are non-erumpent, indefinite, sometimes expanding upto 3 cms in diameter and appearing as black patches. The urediospores occur in sporogenous basal cells and this only indicates the fasciculate mode of development which is without generic significance. The teliospores are catenate, 4-8 spores in a chain, compactly grouped to form an indefinite non-erumpent crust in contrast to lenticular telia of *Phrgagmidiella*. Recently Ramakrishnan (1948) described a rust on *Stereospermum tetragonum* under the name *Melampsora stereospermi*. Pycnia are subcuticular and the aecia uredinoid and subcuticular, the aeciospores closely resembling the urediospores of *Mehtamyces stereospermi*. They described the telia

as occurring in subcuticular crusts but an examination of an authentic specimen, kindly sent by Mr Ramakrishnan, has revealed that the so called telia are in fact the cells of the glandular epithelia, characteristic of the several species of Bignoniaceae. It is probable that the subcuticular pycnia and uredinoid aecia described by Ramakrishnan belong to the life-cycle of *Mehtamyces* in which case *Mehtamyces* becomes identical with *Phragmidiella* in the characters of pycnia, aecia and uredia. The characters of the telia are also close except for the differences in the non-erumpent nature and extent of the sorus. Further the teliospores in *Mehtamyces* are more deeply coloured. Considering the range of variation, it seems advisable to treat *Mehtamyces* as a subgenus of *Phragmidiella* to indicate close relationship.

In discussing the relationship of *Santapauella*, the writers (1945) pointed out that it closely resembles *Cerotelium* in the characaters of the pycnia and telia. But the uredinoid and subcuticular aecia and aparaphysate uredia of *Phragmidiella* separate it from *Cerotelium*.

Arthur J. C. (1925). A. Amer. Fl. **7** : 730

Clements, F. L. and Shear C. L. (1931). Genera of Fungi, p. 334

Dietel, P. (1928). Die natürlichen Pflanzenfmilien. **6** : 56-57 & 77

Mundkur, B. B. and Thirumalachar M. J. (1945). *Mycologia* **37** : 619-628

Ramakrishnan T. S. & K. (1949). *Proc. Indian Acad. Sci.* **29** : 51-53

Sydow H. & P. Monogr. Ured. III : 314 & 419

Thirumalachar. M. J. (1949). *Bull. Torrey Bot. Cl.* **76** : 339-342

87. **PHRAGMIDIUM** Link in *Mag. Ges. Naturf. Freunde* **7**, p. 30, 1816 Fig. 79

Syn. *Ameris* Arthur, *Result Sci. Congr. Bot. Wien*, 1905, p. 342, 1906

Argema Fr. *Syst. Mycol.* **3** : 495, 1832

Earlea Arthur, *Result, Sci. Congr. Internat. Bot. Wien*, 1905, p. 341, 1906

Epitea Fr. *Syst. Mycol.* **3** : 510, 1832

Lecythea Lev. *Ann. Sci Nat.* **8** : 373, 1847

Trolliomyces Ulbrich, *Notizbl. Bot. Gart. Berl.* **14** : 141, 1938

Teloconia Sydow, *Ann. Mycol*

Fig. 79. Phragmidium

Pycnia subcuticular, flat, without conspicuous ostiolar paraphyses. Aecia caemoid without peridium but surrounded by incurved paraphyses ; aeciospores in chains, globoid. Uredia subepidermal, erumpent, pulverulent and paraphysate ; paraphyses cylindric and incurved ; urediospores borne singly on pedicels. Telia subepidermal, erumpent, black ; teliospores one-to ten-celled phragmospores, pedicellate, reddish-brown, thick-walled ; wall layer laminate, verrucose or warty, with two to three lateral germ pores ; pedicel hyaline, usually hygroscopic and swelling at the lower portion.

TYPE SPECIES : *Phragmidium mucronatum* (Pers.) Schlecht. on *Rosa* sp. (Rosaceae)

DISTRIBUTION : Widespread (50 species or more)

NOTES : All the species so far known are autoecious on Rosaceae, especially *Rosa* and *Rubus*. The characters of *Phragmidium* overlap with those of *Frommea* and *Phragmotelium*, also occurring on the Rosaceae, so that it is very difficult sometimes to distinguish them. Further studies are needed to secure a better basis for the separation of these genera.

Frommea differs from *Phragmidium* in having smooth teliospores with distinct single apical germ pores in each cell as against verrucose spores of *Phragmidium* with two to three lateral germ pores in each cell.

The genus *Phragmotelium* established by Sydow (1921) was based on the occurrence of primary uredia without paraphyses and paraphysate secondary uredia with *Phragmidium*-like teliospores. Aecia were unknown in the type but were discovered by Thirumalachar (1942) in *Phargmotelium mysorense*. While genera cannot, as a rule, be based on the type of life-cycle, the following combination of characters distinguish *Pragmidium* from *Phragmotelium*. Teliospores of *Phragmolium* have smooth cell-wall whereas it is verrucose in *Phragmidium ;* teliospores of *Phragmotelium* germinate immediately at maturity whereas those of *Phragmidium* are resting spores. The pedials of *Phragmotelium* do not swell in water.

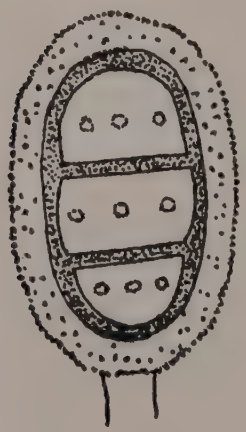


Fig. 80.

Phragmopyxis

There has been some controversy regarding the genus *Xenodochus* Schlcht. also parasitising members of the Rosaceae. Sydow (1915) and Ed. Fischer (1904) merge it into *Phragmidium* though Arthur (1934) and Dietel (1928) keep it separate because of the disposition of the germ pores in the teliospores.

Arthur, J. C. (1907). N. Amer. Fl. **7** : 104

Arthur, J. C. (1934). Manual of Rusts, p. 78 & 91

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 62-63

Fischer, Ed. (1904) *Beitr. Kryptogamenfl. Schweiz* **2**: 406

Sydow, H. & P. (1915). *Monogr. Ured.* III : 89 & 156-158

Thirumalachar, M. J. (1942). *Proc. Indian Acad. Sci.* B. **15** : 187

88. **PHRAGMOPYXIS** Dietel in Die natürlichen Pflanzenfamlien I, **1****, p. 70, 1897 Fig. 80

Syn. *Tricella* W. H. Long in *Mycologia* **4** : 282, 1912

Pycnia subcuticular, minute, conical, with ostiolar filaments. Aecia subepidermal, erumpent, surrounded by incurved paraphyses ; aeciospores catenulate, hyaline, closely verruculose. Uredia subepidermal, erumpent, paraphysate ; paraphyses, peripheral, incurved and encircling. Telia subepidermal ; teliospores pedicellate,

3-celled (phragmospores), verrucose ; wall laminate ; inner layer firm, coloured ; outer layer gelatinous, transclucent, overlaid by cuticle, with more than one lateral germ pore in each cell.

TYPE SPECIES : *Phragmopyxis deglubens* (Berk. & Curt) Dietel on *Benthamantha edwardsii* (Leguminosae)

DISTRIBUTION : Mexico, U. S. A., and Sierra Leone (3 species)

NOTES : The genus is closely related to *Uropyxis* from which it is distinguished by the presence of 3-celled teliospores in contrast to 2-celled ones in *Uropyxis*. Occasionally 2-celled spores are associated with 3-celled ones indicating further resemblance with *Uropyxis*. The presence of subcuticular pycnia and caemoid aecia which are encircled by incurved paraphyses are characters similar to those of *Phragmidium* while the laminate hygroscopic wall layer of the teliospores with lateral germ pores are characters of *Uropyxis*. The genus combines therefore the characters of *Phragmidium* and *Uropyxis*.

Fig. 81.
Phragmotelium

Arthur, J. C. (1907) N. Amer, Fl. **7** : 154

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 65

Sydow H. & P. (1915). Monogr. Ured. **3** : 160

89. **PHRAGMOTELIUM** Sydow in *Ann. Mycol.* **19** : p. 167, 1921
Fig. 81

Pycnia subcuticular, conoid, without conspicuous ostiolar paraphyses. Aecia caemoid, subepidermal, encircled by incurved paraphyses ; primary uredia (uredinoid aecia) subepidermal, aparaphysate. Secondary uredia subepidermal, with peripheral incurved paraphyses ; urediospores borne singly on pedicels. Telia subepidermal, black, erumpent ; teliospores pedicellate, 2-6 celled or more (phragmospores), smooth, reddish-brown, with 2 to 3 lateral germ pores in each cell ; pedicel hyaline, not swelling in water ; spores germinating immediately at maturity without any rest period.

TYPE SPECIES : *Phragmotelium barnardi* (Plowr. & Wint.) Sydow on *Rubus parvifolius* (Rosaceae)

DISTRIBUTION Japan, India, Australia (11 species)

NOTES : The genus was established to accomodate species with aparaphysate primary uredia (uredinoid aecia) in place of caemoid aecia usually found in *Phragmidium*. That this is not a very distinguishing feature became evident by the discovery of caemoid aecia in *Phragmotelium mysorense* Thirumalachar (1942), which in other respects was indistinguishable from other species of *Phragmotelium* so far known. As already pointed out under *Phragmidium*, the teliospore characters offer the clue to their separation. Hiratsuka (1935) considers *Phragmotelium* as a synonym of *Phragmidium*.

Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6**: 61

Hiratsuka, N. (1935). *Jap. J. Bot.* **7** : 230

Thirumalachar, M. J. (1942). *Proc. Indian Acad. Sci.* B **15** : 191

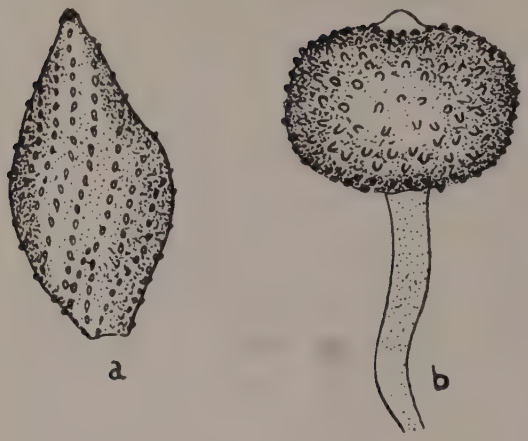


Fig. 82. Pileolaria. a. Urediospore
b. Teliospore

90. **PILEOLARIA** Castagne in *Obs. sur les Ured.* I, p. 22, 1842 Fig. 82

Syn. *Discospora* Arthur in N. Amer. Fl. 7 : 149, 1907

Pycnia subcuticular, without conspicuous ostiolar filaments. Aecia unknown. Uredia subepidermal, erumpent, aparaphysate ; urediospores pedicellate, oblong, fusiform with equatorial germ pores and spirally arranged sculpturings. Telia subepidermal, erumpent; teliospores 1-celled, borne singly on hyaline pedicels, globoid to discoid, flattened on either side ; wall coloured, verrucose, and with a single apical germ pore.

TYPE SPECIES : *Pileolaria trebinthi* Cast. on *Pistacia trebinthus* (Anacardiaceæ)

DISTRIBUTION : North America, India, East Asia, Australia and South America. (17 species)

NOTES : All species so far recorded are on *Rhus* and *Pistacia* (Anacardiaceæ) and *Acacia* of Leguminosæ. Pycnia are subcuticular which distinguishes it from *Uromyces* of which it is considered a synonym by Sydow (1910). Uredinoid æcia have been reported by Arthur (1907) but these are indistinguishable from uredia. According to Dietel (1928) teliospore markings are characteristic in *Pileolaria barbeyana* and *Pileolaria phyllodiorum*. They show apical digitate wart-like processes similar to those found in species of *Dicheirinia*. In fact Dietel considers *Pileolaria* as showing relationship with *Uromycladium* and *Dicherinia*.

In possessing subcuticular pycnia and 1-celled, pedicellate teliospores, often showing digitate warts or irregular markings, *Pileolaria* shows resemblance to *Atelocauda* Arthur and Cummins (also on Leguminosæ), with which it may prove to be cogeneric. The relationship of *Atelocauda* with *Dicheirinia* is not as close as was assumed by Cummins, due to the lack of apical cells of the pedicels in the latter. However *Atelocauda* may for the present be maintained, as we do not know much about its life-cycle.

Arthur, J. C. (1907). N. Amer. Fl. **7** : 147
Arthur, J. C. (1934). Manual of Rusts. p. 69
Arthur, J. C. and Cummins, G. B. (1933). *Ann. Mycol.* **31** : 41
Dietel, P. (1928). Die natürlichen Pflanzenfamilien **6** : 67
Sydow, H. & P. (1910). Monogr. Ured. II : 60-62 & 143-151

FIRST RECORD OF VERTICILLIUM WILT IN INDIA

By M. K. PATEL, I. M. QURESHI and V. P. BHIDE

(Accepted for publication Dec. 31, 1949)

VERTICILLIUM wilt of several widely distributed plants, both cultivated and wild, has been known to occur since a long time in the Western countries. In India, however, *Verticillium* wilt was first noticed in 1938 in an egg-plant (*Solanum melongena* L.) plot on the Agricultural College Farm at Poona. Since then it has been reported from several other localities in the Bombay State where it has caused heavy mortality to the crop, often destroying it entirely. As this wilt is causing much damage to the crop and is being reported for the first time in India, the morphology, cultural characters, physiology, pathogenicity and host range of the fungus have been studied in detail. A brief description of the disease and the causal organism are given below :—

Symptoms—Young plants which are apparently normal in appearance are attacked by the fungus. As they grow older, the infected ones show dwarfing and stunting due to the shortening of the internodes, and generally do not flower and fruit. If infection takes place later in the season, that is after the plant has flowered or fruited, the floral buds and the fruits are formed but they become distorted, flaccid and finally drop off. In the former case the lower leaves are the first to show the symptoms of the wilt with characteristic marginal wilting and curling of the leaf tissues. Wilting proceeds from one margin to the other, till the leaves completely droop and drop off. In some cases, the initial stage of infection is marked out by the presence of irregularly scattered necrotic pale yellow blotches over the lamina of the leaves. The blotches finally coalesce resulting in complete wilting of the leaves. The disease progresses upwards and causes severe wilting or death of the plants. Dissection of diseased tissues reveals the presence of *Verticillium* in vascular region. As a rule the entire plant exhibits the disease, but cases have been observed where only one side of the plant showed the symptoms while the other remained healthy.

The most characteristic symptom of infection of brinjal plants by *Verticillium* is found in the stems and roots of the infected plants. Apparently the infected plants may appear normal and for some time may not show the symptoms on the leaves, but if the stems and roots of such plants are split open longitudinally, a characteristic dark brown discolouration of the xylem vessels, sometimes extending upto the fruit, is seen, being a clear proof of infection.

The incubation period necessary for the development of symptoms varies according to the time of the year and is the shortest in summer though infection invariably takes place only in the cool season. Temperature is the most important factor controlling infection and the progress of the disease. In the field, the disease makes its appearance after about two months from the time of transplanting and its spread and manifestation increases involving the whole field. In the glasshouse, marked symptoms of the disease are produced at a soil temperature of 23°-24°C., 5 to 6 weeks after artificial inoculation has been done, (both by direct wounds and by infection through inoculated soil).

Isolation and growth in culture of the causal organism—The fungus was isolated on potato-dextrose agar from the roots and stems of brinjal plants showing brown vascular discolouration. The fungus grows well on potato-dextrose agar, Richard's agar and brinjal decoction agar. On the last mentioned medium, the fungus

produces a distinct malachite green colouration. The minimum, optimum and maximum temperature for growth in pure culture and for infection are 12°C., 22.5°C. and 30°C., respectively. The pathogen has a wide range of pH for growth viz., 2.5 to 9, although the optimum growth occurs between 4.6 and 5.2 pH.

The causal organism—The pathogen is a soil-borne vascular parasite belonging to the Order Moniliales. On potato-dextrose agar it first produces a white hyaline aerial mycelium with long fine septate hyphæ measuring 1.2—4.0 μ in diameter. The aerial mycelium produces an abundance of unicellular, oval, ellipsoidal, hyaline verticillate conidia measuring 2.5—7.5 μ x 1.1—3.1 μ borne singly at the ends of verticillate conidiophores, in groups of 4-6, measuring 10.6—38.7 μ x 1.1—2.6 μ. After an aerial mycelial growth of 5-8 days, it forms numerous black sclerotial bodies measuring 39.8—173.8 μ x 22.0-55 μ. These are embedded in the medium to a depth of about 1 cm. and make the medium completely dark. In fact, after a growth of fifteen days, the colony consists only of black submerged sclerotia with very little white aerial mycelium.

Before the mycelium forms the final resting bodies viz., the black microsclerotia, it undergoes a transitory stage by forming chains of chlamydospores with round, thick walled cells which are lighter in colour than the cells of the sclerotia. The average dimension of chlamydospores are 6.6—15 μ x 4.6—12.5 μ.

Host range of the brinjal wilt organism—In America and on the Continent of Europe, species of *Verticillium* have been reported to be the cause of wilt of over 120 species of plants belonging to 35 widely unrelated families. To find the host range, several plants were tested by wound inoculation, both through inoculated soil and directly through wounds. Brinjal, potato, tomato, bhendi, cotton, dahlia, tobacco, datura and gooseberry (*Physalis* species) are easily attacked by the fungus causing complete wilt in about 6 weeks, when the soil and glass house temperatures are maintained at 22.5°C.

Identification—The fungus closely resembles *Verticillium dahliae* Kleb. in its morphological, cultural, physiological and pathological chracters. It differs from *V. albo-atrum* R. and B. in many respects, the chief of which being the formation of abundant black sclerotia by the brinjal wilt organism. Further work on the disease is in progress.

The writers wish to record their hearty thanks to Dr. B. N. Uppal, the Director of Agriculture, Bombay State, Poona for generously giving his time and advice during the progress of this work. They also wish to record their thanks to Dr. B. B. Mundkur for help given while writing this note.

Plant Pathological Laboratory,
College of Agriculture, Poona

BOOK REVIEW

Fungi and Plant Disease by B. B. Mundkur. VIII+246, 130 figures. Macmillan & Co., Ltd., London, 1949. Since the publication of "Fungi and Disease in Plants" by E. J. Butler in 1918, this is the first authoritative book on the subject in India and, with his long experience as a teacher of post-graduate students in the Indian Agricultural Research Institute, the author is, no doubt, competent to write such a book. As stated in the preface, the book "is not a compendium of all the diseases of economic plants occurring in India, but deals with those that are considered important and representative." From that standard the book comes up to the mark and satisfies a real need. It should prove useful both to the teacher and to the student of Plant Pathology in the Indian Universities particularly because plant diseases occurring in India have been chosen as examples.

Unlike Butler's book, the treatment of different diseases throughout the work is essentially systematic. Instead of putting the different diseases together under common host, the author has described them according to their place in the system of classification of fungi. This has its own advantage in so far as allied pathogens are dealt with in a connected manner and the life history of the causal organism is thus made easily intelligible to the reader without unnecessary repetition.

The book is divided into 12 chapters. The first three deal with a general account of fungi; their morphology and reproduction, metabolic processes and different disease symptoms produced by them. Chapter IV deals with the methods of studying plant diseases. In Chapter V is described briefly the classification and nomenclature of fungi. The next four chapters deal with important diseases caused by members of Phycomycetes, Ascomycetes, Basidiomycetes and Fungi Imperfecti, the four classes into which fungi are classified. The author has included two useful chapters, one on bacterial and the other on virus diseases of plants. A precise definition of a virus should have, however, been supplied. For example, nowhere has it been stated that a virus is capable of multiplication only in *vitro* and cannot be artifically cultured, a very important property of a virus. The last chapter on plant disease control has been well written in which the author has rightly emphasised the importance of the study of physiologic races with particular reference to stem rust of wheat. The volume is fully illustrated with as many as 130 figures and plates, and at the end of each chapter there is a list of references.

One cannot, however, help remarking that no mention has been made of the diseases of cotton, by no means an unimportant crop, on which so much work has been done in India. Also, some noteworthy contributions do not find a place in the list of references, e.g., Scientific Monograph of the Imperial Council of Agricultural Research on 'Further studies on Cereal Rusts in India' 1940, which gives a detailed account of the position of cereal rusts problem in this country.

Dr. Mundkur is well known to the Mycologists and Plant Pathologists in India and abroad and the volume, therefore, needs no special recommendation. It is to be hoped that this book will find a place in every Agricultural College library and students of Plant Pathology will possess a personal copy for ready reference.

RAGHUBIR PRASADA

THE INDIAN PHYTOPATHOLOGY SOCIETY, NEW DELHI

Receipts and Payments Accounts for the period 28-2-1947 *to* 31-12-1948

RECEIPTS				Rs.	a.	p.
To Patron's Contribution				1,000	0	0
„ Admission Fees :—						
For 1947			1,370	0	0	
For 1948			350	0	0	
For 1949			10	0	0	1,730 0 0
„ Subscription :—						
For 1947			1,260	0	0	
For 1948			1,290	0	0	
For 1949			150	0	0	
For 1950			10	0	0	2,710 0 0
„ Life Membership Fees						3,410 0 0
„ Donations						45 0 0
„ Miscellaneous Receipts						31 3 0
						8,926 3 0

PAYMENTS				Rs.	a.	p.
By Allowance to Staff						72 0 0
„ Postage and Revenue Stamps						121 2 3
„ Printing and Stationery						539 11 0
„ Bank Charges						27 6 0
„ Miscellaneous Expenses						24 10 0
„ Balance :—						
Cash in Hand			92	13	9	
Balance with Lloyds Bank Ltd., New Delhi			8,048	8	0	8,141 5 9
						8,926 3 0

We certify that the above Receipts and Payments account of the Indian Phytopathological Society is in accordance with books and vouchers produced to us.

New Delhi,
Dated 29th January 1949

AIYAR & Co.
Registered Accountants

B. B. Mundkur

INDIAN PHYTOPATHOLOGICAL SOCIETY

Instructions to Authors

Membership in the INDIAN PHYTOPATHOLOGICAL SOCIETY is prerequisite to publishing in INDIAN PHYTOPATHOLOGY but the Editorial Board may relax this rule in the case of contributions of exceptional merit and communicated with a special recommendation by a member. The Editorial Board may invite distinguished scientists to contribute articles of interest to the Society.

Contributions should be on one side of the page, double spaced, with a 1-1/4th inch margin on the left. In form and style, such as punctuation, spelling and use of italics, the manuscript should conform to the best Journals in the U. K. and U.S.A. Authors should strive for a clear and concise style of writing. The name and address of the Institution at which the work was done should be cited immediately after the SUMMARY at the end of the article on left hand side. Tables should be numbered and each table should have a heading stating briefly its contents. References to literature should be made as foot notes *only* when four or fewer citations are given. If there are more, they should be listed under 'REFERENCES' at the end of the paper and referred to by date in brackets in the body of the article. Citations should give the name of the author (or authors), his (or their) initials year of publication and then the full title correctly, followed by the name of the Journals, volume number, a colon and page numbers. If the title is in a foreign language, then the diacretic signs and capitalization should be precisely as in the original. The names of the Journal should be as abbreviated in the WORLD LIST OF PERIODICALS, 2nd ed., 1934, but as that book may not be available to all, contributors are requested to give the titles in full. Abbreviating will, in that case, be done by the Editors. If an article has not been seen in original, then that fact should be clearly stated. An example citing is given below:—

Conovor, R. A. (1948) .. .. .. Studies of two viruses causing mosaic diseases of soybean. *Phytopathology*, **38** : 724-735.

Because of high cost of half-tone blocks, carefully made line drawings on Bristol board in black ink will be preferred. Photographs when necessary should be printed on glossy contrast paper and be of best quality. Full page figures and photographs should be made to reduce to 4 x 6 1/2 inches, the standard size for all plates. Each author is allowed one page of half-tone illustration for each article or its equivalent, and the cost of half-tone blocks and paper in excess will be charged to author. Drawings must be drawn to standard scales, so that they can be compared with one another, *e.g.* x10, x50, x100, x250, x500 etc. It is not always possible to get a magnification at a round figure with a camera lucida but the printer can readily reduce drawings at any magnification to the standard, provided a scale is added to the drawing. The scale should measure from 5 to 10 cm. the longer the better and the printer should be instructed to reduce this line to the desired magnification.

Authors are invited to consult Bisby's 'An Introduction to Taxonomy and Nomenclature of Fungi' (*1945*), pp. 38-41 and Riker's 'The Preparation of manuscripts for *Phytopathology*,' *Phytopathology* **36**: 953-977, 1946, before preparing their mss. and figures.

Articles will be published in the order of their approval for publication but the address of the retiring President and invitation articles will be published when received.

To comply with the International Rules of Botanical Nomenclature, Latin descriptions must be supplied to validate new species and genera.

Authors requiring reprints with or without covers should place an order for the copies wanted at the time of returning the proofs and they will be charged actual cost.

INDIAN PHYTOPATHOLOGICAL SOCIETY

INDIAN PHYTOPATHOLOGY is the official organ of the INDIAN PHYTOPATHOLOGICAL SOCIETY. It is sent free to members in good standing but for others the annual subscription is Rs. 14/- (£1-1-0 or $4.50), post free, and payable in advance. There will be, for the present, two issues in a year, comprising about 250 pages but the number of pages and issues per annum will be gradually increased. Subscriptions should be sent to the Secretary-Treasurer, INDIAN PHYTOPATHOLOGICAL SOCIETY, Pusa Buildings, New Delhi, India.

Printed by N. E. Chinwalla, Manager at British India Press, Bombay.
Published and Edited by B. B. Mundkur, for the Indian Phytopathological Society, Pusa Buildings, New Delhi 5, India.